47TH ANNUAL CONVENTION, CHICAGO, ILLINOIS, JUNE 6-11, 1927

VOL. 17, NO. 3 MARCH, 1927

PROCEEDINGS 47TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

PUBLISHED MONTHLY

BY THE

AMERICAN WATER WORKS ASSOCIATION

At Mount Royal and Guilford Avenues, Baltimore, Md.

SECRETARY'S OFFICE, 170 BROADWAY, NEW YORK
EDITOR'S OFFICE, 16 WEST SARATOGA STREET, BALTIMORE, MARYLAND

Subscription price, $7.00 per annum

Entered as second-class matter April 10, 1914, at the Post Office at Baltimore, Md., under the Act of August 24, 1912
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized August 6, 1918

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JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

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VOL. 17 MARCH, 1927 No. 3

THE BUFFALO WATER WORKS[1]

By GEORGE C. ANDREWS[2]

The inhabitants of a modern city are so accustomed to securing water for all purposes simply by turning on a faucet that they seldom realize the amount of study and work involved in obtaining such a supply, and are also ignorant of the progressive development of and the large amount of money expended on their water works system.

Buffalo is fortunate in having an ample supply of water in Lake Erie easily accessible, but the development of its water works system has involved an expenditure of nearly twenty-six million dollars, which covers the cost of a progressive enlargement of the system from 1849 to the present date.

The history of the Buffalo Water Works may well be divided into three parts.

1. The development of the system based on the erection and operation of the Massachusetts Avenue Station with its intake and tunnels from 1852 to 1903.

2. The planning and construction from 1903 to 1915 of the Colonel Ward Pumping Station and the new intake at the head of the Emerald Channel with the necessary tunnels.

3. The improvements in the operation of the stations and the reduction of water waste with the view of making possible the con-

[1] Presented before the Buffalo Convention, June 8, 1926.

[2] Consulting Engineer, Water Commissioner, Buffalo, N. Y., 1916–1926.

struction of a modern filter plant of ample size at a reasonable investment, and the construction of this plant. This period covers the past ten years.

EARLY CONSTRUCTION

The earliest record of any municipal supply in the city of Buffalo is of 1831, when four cisterns of ten thousand gallons each were built. They were filled with water from the Erie Canal and were used for fire protection.

The Jubilee Springs Water Company, a private organization, was formed shortly after this. Their supply was obtained from springs located 2 miles north of the city and the water was distributed by means of log pipes.

Wells and springs were the sources of water supply up to 1852, when water was furnished from the Niagara River by the Buffalo Water Company, a private corporation organized in 1849. This company erected a pumping station on the easterly side of the Erie Canal at the end of Massachusetts Avenue, the site of the present Massachusetts Avenue Station, and took the water from the Niagara River through a tunnel under the canal. The system had two high pressure pumps, a seven million gallon reservoir, approximately 600 feet by 260 feet by 18 feet, and 13 miles of cast iron pipe from 4 to 16 inches in diameter.

From 1852 to 1869 this privately owned company and the Jubilee Water Company furnished the water supply to the city. In 1868 the city took over these plants and operated them under three commissioners until 1893, when the water system was made a bureau of the Department of Public Works.

Immediately after the city took possession, the old plant was found inadequate and in 1869 competitive plans for the improvement of the water system were received. One provision of the competition to be considered was the possibility of using the flow of the Niagara River to operate the pumps. First prize was awarded to Thomas Dark Sr., who submitted a plan for an intake in the center of the river opposite the station with a connecting tunnel driven through rock.

His plan also included a 21.9 million gallon reservoir and, it is interesting to record, a 28 million gallon per day filter plant, the filter area being 51,684 square feet, with a rate of filtration of 3 pints per square foot per minute. This was the earliest recommendation of

filtered water for the City of Buffalo. The plan of building a new intake and tunnel was adopted and in 1870 the contract for building them was awarded for the sum of one hundred seventy thousand dollars to Clark & Douglas. Mr. Dark, until the time of his death in 1915, was a constant advocate of filtration and a thorough student of the affairs of the water system. It is of interest to state that a grandson of Mr. Dark constructed in 1909 the Emerald Channel intake and connecting tunnels.

The original plans called for an intake pier with openings and gates, 45 by 25 feet at the bottom with ½ inch batter per foot. This pier was to enclose a vertical shaft located 700 feet west of Bird Island pier and to be connected with the pumping station on shore by a tunnel through the rock, 6 by 6 feet in size.

Difficulties were encountered, the size and location of the pier were changed and it was not until 1875 that the work was completed. Two contractors abandoned the work and the tunnel was finally completed by day labor. The total cost of intake and tunnel was $519,403.

The intake, as finally built, was 118 by 22 feet at base and 32½ feet high with a hexagonal top 36 by 16 feet. A sloping nose, or ice and water cutter, projected up stream. On the sides of the pier are ice shields made of steel plates 1 inch thick, projecting 2 feet from the pier and extending to within 2 feet of the bottom of the river. The shields have gates opposite the intakes that can be raised and lowered to prevent ice from entering the shafts. There are two inlets 5 feet by 3 feet with sills 8 feet 9 inches below mean lake level. A 6-foot circular shaft connected the intake with the tunnel, and the capacity, with water 3 feet below mean lake level, was one hundred fifteen million gallons per day.

The tunnel from intake to pumping station was 1340 feet long and was from 4½ to 10 feet by 9 feet in size. As originally designed, it was to be an oval brick-lined conduit, but as constructed, it was unlined.

Great quantities of sulphur water came through the seams of the rock at one place and there an iron shell 6 feet in diameter was placed to shut off the flow. The capacity of this tunnel is 125 million gallons per day. No compressed air was used in construction.

In 1895 a second tunnel was started from the station to the intake. This tunnel was eight feet square and driven through rock at practically the same level as the earlier one. Compressed air was used in construction and work was completed in 1897.

During the period from 1889 to 1894 another major improvement to the system was the building of the Best Street Reservoir. This reservoir occupies an entire city block bounded by Jefferson, Best, Masten and Dodge Streets. It is 1472 feet long, 597 feet in width and has a capacity of 116,200,000 gallons. When full, the water elevation is 685.23 above mean tide at New York and 112.43 feet above mean lake level.

The pumping station was gradually enlarged and improved. In 1903 the pumping capacity was 187 million gallons per day. Buffalo at that time had long been noted in the water works profession as an excessive user of water and in the year ending July 1,1903, the pumpage was 42,624,000,000 gallons, a daily per capita 324 gallons.

Until 1891 water was supplied to all sections of the city at one pressure. However, the extension of the city to higher land in the northeast made it necessary to pump at a higher pressure for this section, and piping and valves were arranged so that the city was divided into two pressure systems, the higher having a pump pressure of from 75 to 95 pounds and the low, or reservoir service, a pump pressure of 50 pounds. Gradually this area grew in extent until since 1921 only the southeastern section is supplied at the reservoir head.

In 1903 the system consisted of the Massachusetts Avenue Station, the Niagara River intake with two tunnels, the Best Street Reservoir and distribution system. Plant investment at this time was $7,388,000.

DEVELOPMENTS BETWEEN 1903 AND 1915

This year marks the second period of the development of the Department. In 1902 Buffalo experienced a typhoid fever epidemic which aroused public opinion to the needs of a better water supply. Two reports were made in that year; one of the Department of Public Works by Rudolph Hering, Gen. George S. Field and Col. Thomas W. Symons, recommending the construction of a new intake in the Emerald Channel at the junction of Lake Erie and Niagara River approximately 10,400 feet southwest of the old intake, to be connected to the shore by a tunnel 12 feet by 12 feet 6 inches and 6651 feet long, where a new pumping station was to be built, the present Colonel Francis G. Ward Station, with a further tunnel 9 feet by 9 feet 4 inches and 4286 feet long from the shore shaft to the Massachusetts Avenue Station; the stations to be so equipped and connected with the distribution system that either station could supply the city if necessary.

The other report by George W. Fuller was given to the Health Department and covered the typhoid fever epidemic, investigation of the sources of pure water and a favorable opinion on the plan of the consulting engineers.

These reports were subject to long debate in the council chamber and in the press, but the work was finally authorized and plans started in 1906.

In June, 1907 the contract for the tunnels and the new intake was let and work commenced that season.

The new intake, since designated the Emerald Channel intake, has operated very successfully and is briefly described as follows: Situated at the head and center of the Niagara River with water normally 28 feet deep: it consists of two concentric steel shells, one 70 feet in diameter, the other 110 feet in diameter, with the space between filled with concrete. The shells were sunk onto a level concrete footing and rip rap 8 feet deep was deposited inside and outside the shells. Within the intake a 6 inch concrete layer was placed over the rip rap. In the center a 13 foot shaft was sunk through the rock 40 feet to the tunnel and it was continued upward 31 feet 6 inches above the rip rap by means of a steel shaft of the same diameter.

The outer shell has twelve ports 6 feet by 6 feet in size, equally spaced with their sills 20 feet below ordinary lake level and equipped with gates so that they can be controlled from a balcony in the intake.

The flow of water through the steel shaft to the tunnel is controlled by four openings 5 feet 3 inches by 6 feet equipped with gates.

The superstructure encloses the operating gallery, chlorination room and living quarters. This intake was put in operation May 12, 1913, and in August, 1914, a chlorinating plant, the first chemical treatment of the city's water was placed in operation. In October, 1924, the chlorinating plant was placed on shore, the building locked tight and the intake has since served its purpose without manual attention. For the period from 1913 to 1924 two men were kept constantly at the intake to operate the chlorinator and to regulate the gates. This intake has only at rare intervals been bothered with either slush or anchor ice. During the winter the lake is usually frozen over up to the intake.

The tunnels from the intake to the shore and from the shore shaft to the Massachusetts Avenue Station were started in 1907 and completed in 1913. The former is 12 feet by 11 feet 6 inches in size

6651 feet in length, and the latter is 9 feet by 9 feet 4 inches and 4286 feet long. Both tunnels were driven through limestone with inverts at elevation 506.7 and are concrete lined. The maximum capacity of the intake and main tunnel is estimated at 450,000,000 gallons.

In July, 1909, the contract for building the new pumping station was awarded and it was completed and put in operation in 1915. This plant is one of the largest and most completely equipped in the country.

Briefly, it consists of an engine house 95 feet by 364 feet, containing 5 thirty million triple expansion engines, 3 centrifugal three thousand gallon per minute high pressure fire pumps and foundations for three additional pump units; a boiler house 100 feet by 200 feet containing eight B & W. boilers, 750 h.p. each, with foundations for eight additional, equipped with McKenzie traveling grate stokers and Foster superheaters. Besides the above, the building encloses valve and pipe room, Venturi meters, feed pumps, electric generators, intake well, offices, storeroom, machine shop and chemical laboratories.

In 1908 the Kensington water tower was erected to serve as a relief on the high services. This structure is a steel cylinder 40 feet in diameter, 85 feet in height, surrounded by an ornamental stone and brick tower. Its capacity, when filled, is 704,970 gallons and the base is 106.31 feet above normal lake level.

During the period from 1903 to 1915 the Massachusetts Avenue Station was practically rebuilt and re-equipped, so that in 1916 the water plant consisted of two intakes with tunnels, two pumping stations with a combined pumping capacity of 330,000,000 gallons per day, one reservoir, one water tower and distribution system, and was valued at $17,219,061.03.

WATER WASTE REDUCTION

In 1915 the pumps at the new Porter Avenue Pumping Station which was later named the "Colonel F. G. Ward Pumping Station" in memory of the late Commissioner of Public Works, under whose administration it was initiated and constructed, were first put in regular operation and since that date the station has been continuously operated.

By the completion of the Ward Pumping Station it was no longer necessary to depend entirely upon the pumps at the Massachusetts Avenue Station and the pumpage from this station has gradually decreased as the demand for water has diminished during the past ten years.

From 1916 to 1921 the efforts of the Bureau were devoted exclusively to improving the system, decreasing the consumption of water and increasing the efficiency of the pumping plants, so that it would be possible to design and erect a filtration plant of sufficient size and at a reasonable cost as a final step in improving the water system.

In 1916 Buffalo had a magnificent water system, but its operation was lax and inefficient in nearly every respect. This included financial methods, the system of billing and collection of water rates, inspection, maintenance and extension departments, and the operation of the pumping stations. The water consumption was at a tremendous figure, in 1916 the total pumpage being over 61 billion gallons or a daily per capita consumption of 339 gallons. The stations were operating without coördination and little or no efficiency was being striven for in their operations. The commission form of government had been introduced in 1915 and a body of five representative citizens had been elected to govern the affairs of the city.

Shortly after their inauguration the speaker became Water Commissioner and took steps to improve existing conditions. Satisfied that a tremendous waste of water existed, a pitometer survey was made of the entire city, with the result that the consumption was reduced to less than fifty billion gallons in 1918. Realizing that the effect of the pitometer survey would soon be lost if it was not followed up closely, a permanent pitometer department was organized and the consumption data covering the various sections of the city, secured by the first survey, were kept as a guide for their work.

The original survey showed many sections where there was household wastage to so great an extent that the night rate was 80 per cent of the average daily rate. Such sections were marked for special inspection and frequent re-measurements. The total pumpage, as shown, decreased each year until in 1925 the daily per capita consumption had been reduced to 214 gallons.

Where persistent water wastage was encountered, meters were installed. The number of meters has been increased from 4219 in 1916 to 14,945 in 1925. While our consumption is still high compared with other cities, it is well within the capacity of our pumping plants and very little advantage would be obtained by reducing it lower at the present time. It is the aim of the Department to hold the total pumpage at approximately the present figure, notwithstanding the normal growth of the city and this means that the per capita consumption will be reduced year by year; so far, there has been little difficulty in doing this.

PUMPING STATION IMPROVEMENTS

In 1915 the total pumping capacity of the Ward Station was 150,000,000 gallons and that of the Massachusetts Avenue Station 180,000,000 gallons, and the daily average pumpage approximately 170,000,000 gallons. As the result of the water wastage campaign it was possible to do the bulk of the pumpage at the Ward Station on account of its more economical equipment. At the present time it is possible to supply the entire city for 80 per cent of the year from this station. However, as the Massachusetts Avenue Pumping Station would rapidly deteriorate if shut down, it has been considered advisable to maintain a skeleton crew at that point and operate one pump throughout the year.

When the pumpage was at its maximum it required approximately one ton of coal per million gallons pumped and as the pumpage was reduced the coal consumption per million gallons increased slightly, due to using a larger percentage of coal consumed for heating and other incidental purposes. To reduce this coal consumption a survey was made in 1917 of the two stations and certain recommendations for their improvement made.

The steam piping layout at the Ward Station, which is equipped with eight 750 h.p. B. & W. boilers set in line, consisted of an independent steam header at the front and back of each boiler. These two headers extend to the pump well between the boiler house and the pumping station and there drop into two independent steam headers running parallel to the five triple expansion pumps. These headers were placed on steel I beams about ten feet above an open suction well. One header supplied two pumps and the other header supplied three pumps, there being no inter-connection between same, so that in case of the failure of one header either two or three pumps were put out of commission. This layout had six 16-inch blank ends and sixteen connections from the boilers. A plan was drawn up, making a modern loop steam line layout properly equipped with valves, so that steam would feed into the header in both directions, and in case of the failure of any boiler or pump it was possible to isolate them by closing two valves and still keep the other four pumps and seven boilers in operation. This change was made while the plant was in operation and upon its completion the coal consumed at the Ward Station dropped from 1.2 tons per million gallons to approximately 0.9 ton, and the saving in coal in three years' operation paid for the change.

STRENGTHENING THE DISTRIBUTION SYSTEM

During the time of high consumption complaints were made as to the lack of water pressure in various parts of the city, especially in the northeast and southeast sections which are furthest from the station. To improve this condition experiments were made in cleaning certain sections of pipe and in 1920, 1921, 1922 and 1924 most of the large mains which had been in service twenty years were cleaned. The result of this was that the water pressure in the southeast section, which is connected with the Best Street Reservoir, was increased from 15 to 28 pounds.

In the enlargement of the Massachusetts Avenue Pumping Station, the discharge mains leading from the station were carried under the New York Central tracks and 50 feet up a steep bank to Front Avenue. Owing to complications with the New York Central Railroad no permit could be secured or agreement made with them which would permit us replace the old mains under their tracks and as the number of pumps was increased and the sizes changed a net work of pipes had been laid in the slope and the street. When the old station operated alone there was constant danger of these pipes breaking and flooding out the station. It had been equipped with a large number of valves to minimize this danger.

At the time of changing the city from one service to two services additional valves and piping were installed so that there were a great number of valves to be operated in changing the pumps from high to low service or to be operated in case of a break; in fact, any trouble there usually called out the entire number of maintenance men in the Department. A study of the valves and pipes was made and in 1921 the main valves in this layout were equipped with electrical opening and closing mechanism operated from a central switchboard. This equipment served a twofold purpose; first, it allowed the valves to be opened and closed daily, keeping their mechanism in good condition, and second, in case of breaks in the line or shift from one pressure to another, valves could be operated from the switchboard.

HIGH PRESSURE FIRE SYSTEM

A high pressure pipe line for fire protection, equipped with hydrants, was laid in 1897 and gradually extended, until in 1916 it protected the high valued area bounded by Huron, Franklin, Ellicott Streets and the Buffalo River. Water was supplied at 300 pounds

pressure by fire boats. Upon the recommendation of the fire chief in 1920 three 3000 gallon per minute centrifugal pumps, driven by steam turbines, were installed at the Ward Pumping Station and an independent 20 inch line laid from the station connecting with the system at three points; Huron and Pearl, at Eagle and Pearl and at the Lower Terrace and Main Street. The old hydrants were removed and replaced by the modern high pressure type, equipped with four 3½-inch nozzles. The change allowed more freedom of movement of the fire boats, made the system instantly responsive to calls for service and allowed the system to be kept constantly filled with water, as all pipe was laid below the frost line. This work was completed in 1922 under the supervision of the Bureau of Water.

WATER CHARGES

The financial affairs of the Water Department in 1916 were found to be in a very unsatisfactory and unbusinesslike state and an operating deficit of over $200,000 had been incurred in the five preceding years; maturing bonds were being renewed, and interest and sinking fund requirements on the new bonds were increasing faster than the increase in receipts. A thorough study was made of this matter and a new rate schedule was recommended.

The bulk of the services were, and still are, on the flat rate basis and the meter rates were so extremely low, two cents per thousand gallons, that the installation of meters gave no added income. A report was made recommending an increase in flat rates of approximately 40 per cent and a three step sliding scale for meter service. The lowest charge for metered water was five and one-third cents per thousand gallons. The report was adopted by the Council and the new rates placed in effect September, 1920. The rates gave a surplus of from three to four hundred thousand dollars a year after paying operating charges, fixed charges and sinking fund deposits. This balance has been used for paying maturing bonds and for making pipe line extensions.

FILTRATION

The need of filtered water had long been recognized in Buffalo, but the tremendous pumpage, due to the excessive waste of water, had made the cost prohibitive. The size of a filter plant where there is no large storage reservoir is directly proportional to the maximum demand and the operating cost is partially proportional to the yearly

pumpage. In February, 1917, our maximum daily demand was 257,593,000 gallons and for the year ending June 30, 1917, the total pumpage was 61,470,594,000 gallons. These figures were reduced to a maximum daily pumpage of 206,580,000 gallons and a total pumpage of 51,687,000,000 gallons for the 1919–1920 fiscal year and water waste was under such control that definite figures for a suitable plant could be recommended.

The industrial depression of 1921, with the resulting unemployment, brought the question of making permanent public improvements to the fore, and the City Council put the question of building a filtration plant of a normal capacity of 160,000,000 gallons per day at an estimated cost of $4,000,000, to a vote in November, 1921. The vote was favorable by a substantial majority and an engineering force was organized in January, 1922.

The Buffalo filter plant will be described in detail in one of the papers to be presented at this convention and I will mention it only briefly here.

It is located on Jersey Street just south of the Ward Pumping Station and consists of a covered raw water conduit 506 feet long 12 feet by 12 feet in size connecting the tunnel from the Emerald Channel Intake with the low lift pump station of the filter plan. The low lift pump station is 50 feet by 93 feet in size equipped with five centrifugal electrically driven pumps of a total capacity of 240,000,000 gallons per day, with a lift of 17 feet; a coagulating basin 425 feet by 325 feet with a three-hour detention period; forty filter units 33 feet by 50 feet of a normal rate of filtration of 4,000,000 gallons per day, capable of 50 per cent overload; a filtered water reservoir 515 feet by 330 feet with 18,000,000 gallons storage capacity directly underneath the filters, so built that forty additional units can be added when water needs demand same; a filtered water conduit leading to the pump well of the Ward Station and connections made with the pump well and the tunnel leading to the Massachusetts Avenue Station; a head house containing the wash water tanks, chemical feed and chlorine machines, laboratories, offices, etc.

The construction was carried on mainly by contract. The first contract consisting of excavation, substructures, conduits, etc., was let in August, 1922, and work started that fall. Other contracts embracing valves, gates, pumps, electrical equipment, filter equipment, piping, sand and gravel, superstructures, etc., to the number of twenty-five were let at various times. It is interesting to note that

in the operation of the filter plant it has only been necessary to make two changes in the pumping equipment of both the Ward and Massachusetts Avenue Stations; first of these, was changing the condensers on the triple expansion pumps from jet to surface type; the other was an extension of the suction pipes of the pumps of the Ward Station so as to get the full benefit of the clear water reservoir capacity. The plant, as designed, has a normal capacity of 160,000,000 gallons per day, but all conduits, pump connections and filtered water reservoir have been built so that the capacity of the plant can be increased 100 per cent by enlarging the coagulating basin and building the forty additional filter units and replacing the smaller pumping equipment with larger units so that eventually the Buffalo filter plant is likely to be the largest individual filter plant in the country. The cost to date, including all engineering fees, force account and balances due on uncompleted work is $3,736,000, which will be practically the cost of the completed work.

In the design of the plant consideration was given mainly to substantial construction, economical operation, not only of the filter plant, but also in conjunction with the pumping stations, attractiveness of appearance inside as well as outside, and also to utilizing the surrounding grounds in a general water works park development. These conditions, we believe, have been met to a marked degree and at a most reasonable expenditure of money.

With the completion of the filter plant, the Buffalo Water Department will consist of two pumping stations with a combined capacity of 330,000,000 gallons, two intakes with tunnels, one reservoir with a capacity of 116,200,000 gallons, one water tower, one filter plant with a maximum capacity of 240,000,000 gallons per day and distribution system sufficient for its needs. The plant investment, as of April 1, 1926, was $23,500,000.

With the proper operation this plant should not only give wholesome clear water, but also should be sufficient for the needs of the city, at its present rate of growth, until 1935.

A LARGE ELEVATED STORAGE TANK AT CHARLESTON, S. C.[1]

By James E. Gibson[2]

The many advantages obtained by the use of elevated tanks and standpipes to reinforce the distribution system have not been fully appreciated by the water works fraternity. The earlier tanks were entirely too small to offer any service along this line, but in recent years the quality of workmanship, material and design has so much improved that they now offer a very great advantage in this work, particularly in view of the high cost of laying large mains in improved streets with the attendant interference of traffic, etc. We propose to give you a concrete case at Charleston, S. C.

Here we had the direct or Holly system. The pumping station is located about 12 or 13 miles from the center of distribution; pumps are of the fly-wheel type. The pumping mains consist of a 24-inch cast iron line extending from the pumping station to the city and a 20-inch continuous wood stave pipe line extending from the pumping station for two-thirds of the distance to the city. The consumption within the city proper is fairly regular, particularly the domestic consumption, but just outside of the city limits between the center of distribution and the pumping station are large fertilizer, oil refining, lumber and manufacturing plants which require large quantities of water. While we have insisted upon their taking this water at a relatively uniform rate and installing tanks to supply their peak demand, it is not always possible for them to do this, with the result that their demands for water have caused a rather erratic pressure condition in the city proper. The peak demand was about $10\frac{1}{2}$ million gallons per day; the minimum $3\frac{1}{2}$ million gallons between midnight and six o'clock in the morning; and the average about $5\frac{1}{2}$ million gallons. The maximum pumping pressure at peak load was 125 and the minimum 50 pounds. It will be appreciated that to maintain the 125 pounds throughout the twenty-four hours would

[1] Presented before the Buffalo Convention, June 11, 1926.

[2] Manager and Engineer, Water Department, Charleston, S. C.

have caused excessive pressure at the time of minimum consumption. The result was that we had to operate the pumping station under a varying pressure. If, for any reason, a heavy draft had come other than at the hours normally expected, the pressure in the city would be abnormally low at such times.

Some two years ago we considered installing additional mains, but the estimated cost was in excess of the benefit to be obtained, for we realized that their installation would not eliminate, but would merely reduce, the extreme difference in pressures. We considered, therefore, the question of placing a large standpipe or tank downtown near the center of distribution. By the use of a mass diagram based upon a week of high consumption as recorded by meter charts, showing the flow through the pumping main at the pumping station and at the city limits, we found that with a storage capacity of about $1\frac{1}{2}$ million gallons near the center of distribution, we could maintain a uniform pressure within the city by pumping at a uniform rate under a uniform head. We began to investigate the size of tank required to give us this quantity and found that two tanks 56 feet in diameter approximately 120 feet high, or one tank 80 feet in diameter, 120 feet high, would give us the desired results. Upon taking this matter up with a number of the tank builders, we found that the 80-foot diameter tank was feasible and that the cost was less than that of two tanks. Early in 1925 contract was let to the Chicago Bridge & Iron Works for an elevated steel tank with ellipsoidal bottom, having a total height of steel work of 115 feet.

A site which we thought would offer suitable foundation for a tank of this size was purchased. The piers supporting the column loads were built of concrete, pyramidal in form, with their base 5 feet below the average natural surface. The total height of the tank above average street level is 130 feet.

The question as to the safe bearing value of the soil was one of the most interesting points. The following is a log of the holes drilled at the site:

12 inches top soil
18 feet of yellow sand, dry
9 feet of tough dry clay
4 feet of light yellow sand containing small shells and water
14 feet of dark gray sand and water
10 feet of clay mud and shells directly on top of marl 56 feet below surface
Thickness of marl in this section varies from 300 to 600 feet.

Tests for bearing values were made by means of a weighing platform surmounted on a square timber post, having an area of approximately 0.5 square feet. Tests were made at three different locations none of which however were within the area to be occupied by the foundations of the tank. Results of the tests are given below:

LOADING, POUNDS PER SQUARE FOOT	SETTLEMENT IN INCHES AT LOCATION		
	No. 1	No. 2	No. 3
4,000	1.125	1.00	0.25
6,000	1.800	1.125	0.60
10,000	2.64	1.920	1.56
12,000			1.92
14,000			2.08
16,000			2.52
16,000	Final after twelve days		2.64

Minimum period between loading twenty-four hours.

No rain occurred to soften the soil during period of test.

Locations 2 and 3 are more representative of the soil conditions upon which the tank will stand.

Thus, the settlement varied from 0.25 up to 2.6 inches, depending upon the load and the location. The tests indicated that there would be some settlement of the concrete foundation, but the question was to distribute properly the load on this soil so as not to exceed 2¼ tons per square feet, including live and dead loads and foundations. Pyramidal form of construction for column piers was selected and in order to keep both the yardage and the stresses in the concrete within reasonable limits, deformed steel bars were used. I wish to say at this point that I think it would be advisable for the tank builders to give the foundation greater consideration, since this feature of the design has considerable influence on the final cost of the entire structure.

After the tank was completed we filled it and took observations on each column pier, noting the settlement as the tank filled. The maximum settlement of any one pier was 1.656; the minimum 1.333; average 1.512 inches. We had anticipated minimum settlement of an inch and a maximum settlement of 1.5 inches. We then emptied the tank for the placing of bitumastic enamel on the inside, which work was completed the latter part of last month. The second series of levels indicated that the foundations rose on the average of 0.374

inches about five weeks after the tank was emptied to apply bitumastic enamel. Another series of levels, taken when the tank was filled for the second time and just prior to its being placed in service, showed the foundations to have settled back again to the same elevation as occurred under full load the first time. We understand that this practically agrees with another case, where, after taking the load off after initial filling, the foundation tended to rise and on the second filling, the settlement exceeded the first slightly, after which no further movement occurred.

Quite a unique feature of this standpipe, we consider, is the overflow trough, and it must be borne in mind that Charleston has a very mild climate and only occasionally do we have ice. I have lived in Charleston now for nine years during which time we have had ice formed on our storage reservoir only once and then of a thickness just sufficient to bear your weight. During the usual winter we get only a very thin skim of ice and only then in the more exposed places. The tank is built in a residential section that is not yet entirely built up. If it were not for the overflow trough, future residences might be damaged by water being washed over the edge of the tank by high winds. The overflow trough constructed on the outside edge of the tank is 18 inches deep and 18 inches wide, and its outer edge projects to a minimum height of 6 inches above the inner edge of the tank. This trough also serves as a stiffening girder around the top to maintain the tank in its true shape in the same manner as the balcony girder. Leading from this wash water trough down one side is a 12-inch conductor pipe which will carry this water to the sewer or drain. By this means we hope to preclude complaints from property holders caused by any overflow that may occur by too continuous pumping or by wave action. This type of construction, of course, would be impossible in a country where ice forms every winter and for a considerable time.

You will note that we have not covered the tank. This probably will be criticized by some, but we gave the matter considerable thought, and the tank is designed so that at any time in the future we can put a roof on it. We have, however, taken the precaution to have all plates and members at the top turned on edge to discourage the alighting of large birds on this tank, as we understand that a bird must have sufficient grip to be permitted to alight and retain its position.

The design of the tank was based upon the following stresses:

Working stresses in plates and members, bottom of tank, and first ring where columns of tower join shell of tank	13,000 pounds per square inch
Vertical plate above bottom ring	18,000 pounds per square inch
Steel and structural tower	18,000 pounds per square inch
Bearing value on soil	$2\frac{1}{4}$ tons per square foot

The total weight of the tank when full, including foundations, is 22,120,000 pounds; the weight of the steel work 1,550,000 pounds; and the weight of the water 17,170,000 pounds; calculated wind load 100 pounds per square foot on one-half the projected area of the tank and bottom. The center or riser pipe is figured to carry one-sixth the total load of the tank, or approximately 3,200,000 pounds; columns are Bethlehem H section and all diagonal tension members and struts are of standard structural steel shapes. Minimum thickness of any plate in tank shell and riser pipe is $\frac{3}{8}$ inch, and in the overflow trough $\frac{1}{4}$ inch. Bethlehem H sections were selected for the columns because of their simplicity and accessibility of all surfaces for painting.

With the tank in service, it is our intention to operate our pumping station units at a uniform speed and pressure throughout the twenty-four hours and maintain downtown on the street mains a pressure varying from 50 to 40 pounds. The tank is designed to cover a maximum demand for any one day in the week, based on a weekly pumping record.

We have purchased sufficient land at the site of this tank for a second tank of the same size when it becomes necessary.

DIVERSION OF MUNICIPAL WATER WORKS FUNDS[1]

D. C. Grobbel:[2] The growth of urban population in America in the past decade or two has very much increased the problems of city government. With the need of improvements in municipal activities has come a large increase in the rate of taxation. To keep this rate down has been the object and aim of every municipal administration. This aim may be prompted by political expediency or an honest effort to lighten the burden of the home-owner, the merchant or the industrialist.

Constant surveys are made to discover new ways and sources for obtaining funds without directly levying through taxes. One of the methods of obtaining such funds has been to sequester the profits, if any, of the only general utility enterprise that most of the American cities have, namely, that of supplying water.

The justice of such sequestering of money earned by municipal water utilities has been stoutly contested by practical water works men, but recent years have shown an increased tendency to make use of this method of obtaining funds for other municipal operations.

The basis for the authority to appropriate such surpluses that may occur is born in the erroneous idea that a municipal plant belongs to the tax paying citizens of a municipality, disregarding the actual fact that there is a distinction between the water consumer, namely, he who purchases services and water from the utility, and the general tax payer. That such distinction exists must be apparent to any who give thought to the operation and financing of a municipal water works plant, and this distinction has been upheld by courts and utility commissions. A study of the finances of approximately two hundred water works in the United States shows that practically all of these works are self-supporting, that besides the payment of the operation and maintenance expenditures, sinking fund on bonded debts and interest charges must also be met from the earnings of these works. The water consumer of these works, therefore, provides the works and although the title may be in the municipal corporation,

[1] Topical discussion presented before the Buffalo Convention, June 7, 1926.

[2] Assistant Secretary, Board of Water Commissioners, Detroit, Mich.

the fact, nevertheless, exists that the works are paid for through water rates by the water consumer.

The Maine Public Utility Commission, in the case of Knowlton vs. Farmington Village Corporation (P. U. R. 1918E, p. 884), a case wherein the funds of the water works were used for other municipal operations, states this very plainly. In rendering its decision, the Commission says that,

> The fallacy of the theory that this water service is furnished by the respondent as a corporate entity, just as it might furnish fire department, police or public school service, lies in the fact that the Farmington Village Corporation does not actually provide this service. It holds the legal title and operates the plant, but as a corporation it never paid a dollar for the property, and does not expect to. It collects the revenues from the water takers and disburses them. The consumers not only have paid all that has been paid on account of the cost of the water works, but very much more. They have paid in water rates the actual cost of that service, and during several years past, the cost of all other corporate activities of the Village Corporation.

Where such appropriating of water works funds is practiced, it is usually based upon the fact that when the works was first constructed, or purchased, the funds for the cost were either raised through a tax levy or by pledging the credit of the municipality, namely by bonds. In other words, the responsibility for the municipality having a water works was placed upon the whole tax paying citizenship and not only upon those estimated as the possible custtomers of the utility. Where this is true, it must be borne in mind that the municipality only loaned its aid as an established financial agency for the purpose of securing a most needful utility for the community.

Coincident with the municipal legislation regarding the securing of a water works, or even before construction is started, or purchase of an already constructed but privately owned plant is consummated, the question of the water rate that is to be paid is discussed and efforts made, though not always successful, to adopt such rate that will not only make the works self-sustaining, but ultimately also to retire or pay the indebtedness incurred in establishing the water system. The rules regarding what such rate should be are well established, not only in the text books on water works practice, but also, and with more weight, by the utility commissions and the courts in the various states.

The earnings from the water rates for a municipal plant should be

such as to provide for operation and maintenance, depreciation, taxes and interest on the funds invested by the municipality. There can be no discussion on the matter of operation and maintenance and depreciation. On the matter of taxes, it is uniformly held by authorities on municipally owned utilities that the non-levying of taxes against a municipal utility is discriminatory in favor of the user of the utility. True, where the municipality foregoes the levying of taxes, the utility is usually supposed to furnish a quid pro quo in the shape of free service and water to a multitude of municipal operations, but, here again, there may be and almost always is a discrimination against the water consumer, who is thus compelled through the payment of the rates to provide for things that should have been paid through taxes by the tax-paying citizenship of the municipality.

There remains, therefore, the interest on the municipal investment. This brings up the question of public policy which the municipality may wish to pursue in the operation of its water utility. Ordinarily, a water works is acquired for the benefit of the citizenship consumer. Such benefit may be a low rate, or a more adequate or pure supply at a low rate. Indeed the benefits of low rates or an adequate supply are the usual and persuasive inducements presented to the citizen to establish a water works or purchase an established one.

Therefore, the municipality must determine whether the water utility is to give service at cost or service for profit; if the former, it is acting on the theory that a municipal government, or for that matter, all government exists to serve the general welfare of the public. If, however, the municipality desires to enter the business field by the establishment of a profit making water works, it stands to reason that such business must be carried on under the rules, laws and principles established for such business. Moreoever, such business must be conducted for the benefit and welfare of the inhabitants of the municipality.

Where the municipality decides to give water service at cost, such plan can only be a theoretical one, for it follows that in either a fast growing, or a decreasing community, there can be no stability in the rates and consequent earnings from these rates. There must be a constant shifting in the expenditures and earnings. True, there may be communities that do not change in their growth of population, commerce or industry, but these are few. In such communities, constancy in earnings and expenditures of water works plant may be attained.

In considering the service for profit policy, as stated before, the municipality is under the same rules of business as a private owner, with the added obligation that it must conduct the business so that it redounds to the public welfare. Such service must produce earnings which will cover all legitimate operating and maintenance expenditures, depreciation, interest on the bonded indebtedness and a return on the fair value of the plant. The latter item must partly be used for a sinking fund to retire the usual bonded indebtedness and the remainder of the profit distributed or placed in reserve.

It is the distribution of this surplus profit that may be present that raises the question before this body. As has been noted, there exists a difference between the citizen taxpayer and the citizen water consumer. To distribute the surplus earned to the citizen taxpayer in the shape of added police, fire or sanitary protection, is manifestly wrong, because an additional tax burden is placed upon the water consumer as a class, making the latter subject to double taxation. Again, there is no relation between such municipal operations as fire protection and other municipal operations which redound to the benefit of the general taxpaying citizen and for the support of which tax levies are made, and the consumption of the water by the water rate payer.

Where, then, is this surplus, if any, to be placed? Ordinary business prudence, it would seem, would prompt the municipality to take note of any changing conditions in managing the affairs of the water works, adopt improved devices in order to bring the plant to a high state of efficiency, and secure such equipment as will tend to greater economy in operation, in a word, use the surplus to secure such betterments in the works as a prudent and intelligent business organization would apply to its own industrial plant.

The surplus so applied would be for the welfare of the water consumer, in that it would make possible not only a reduction in rates, but also secure a greater safety and certainty in the production and distribution of water. At the same time, there would occur no discrimination in favor of the taxpaying citizen, as against the water-consuming citizen, a discrimination which has been condemned by courts and public utility commissions, where the latter have authority over municipally conducted utilities.

For the purpose of securing some information regarding the status of water fund diversion throughout the United States, a questionnaire was sent to over two hundred cities, of which number one hundred

and six replied. Of this number, ninety-four reported themselves as self-supporting in every way, eight had annually recurring deficits and one was only self-supporting insofar as the works pays its operating expenditures. One hundred and four works reported on the question of separating funds. The funds of ninety works were kept separate in every way, but fourteen had their receipts paid into the municipality's general fund from which these were disbursed for any purpose deemed proper by the municipal authorities.

Ninety-nine cities reported on the question whether there had been any diversion of water works funds and twenty-nine answered, yes, and seventy, no. The questionnaire further showed that seventeen cities prohibited such diversion by local laws. There is, however, diversion in almost all of the cities studied on account of their not only accepting but demanding free service. Excluded from the cities questioned was Detroit, where the city charter provides that water funds may be used only for water works purposes. However, here also, the works must furnish free water to an amount approximating 15 per cent of its production.

John Chambers.[3] The Louisville Water Company is owned by the City of Louisville, the entire capital stock being held by the Commissioners of the Sinking Fund.

The property is under the management of a Board of Water Works, the members being appointed by the Mayor, subject to the approval of the Board of Aldermen, the Mayor himself being a member, ex-officio. Only one member of the Board of Water Works can be appointed each year. The term of office is four years. This is a wise provision, as in the event of a change in the politics of the city administration, only one member of the Board of Water Works can be changed each year. All officers of the Water Company are elected or appointed by the Board. The powers of the Board are broad and not subject to outside influence.

The Mayor of the city is elected in November and takes office during that month, for four years. An election for mayor was held in November, 1917, the successful candidate being inducted into office during that month.

In the year 1918 the Board of Water Works, at the suggestion of the Mayor, declared a dividend of fifteen per cent on the capital stock

[3] Chief Engineer and Superintendent, Louisville Water Company, Louisville, Ky.

of the Louisville Water Company payable to the Commissioners of the Sinking Fund. The purpose of this action was to avoid an increase of the tax rate and to make possible a reduction instead. The dividend, amounting to $191,265.00, was paid from earnings for the year 1917 which were $442,561.00. The same dividend was paid in the years 1919, 1920, 1921 and 1922. In the year 1923 the sum paid into the sinking fund was $173,157.24, the reduction being agreed to by the Mayor. Since that time the full fifteen per cent has been paid and there is every reason to believe that the practice will be continued. The total amount paid to the present time is $1,512,012.24. The bonded indebtedness of the Louisville Water Company is small, being $1,079,000.00, and, in addition to the dividend, the Water Company pays each year to the sinking fund a sum sufficient to provide for its own bonds.

It is probable that when the Mayor requested the first dividend he had in mind the loss of income to the sinking fund when liquor licenses should be discontinued, the advent of prohibition being apparently inevitable. In the year 1917 the sinking fund's income from license taxes was $509,007.00, of which $305,000.00 were obtained from liquor licenses. In 1918 the total income was $625,654.00 of which $419,000.00 were from liquor licenses. In 1919 the sinking fund received from license taxes $339,901.00 of which only $3,840.00 were from liquor licenses. From this time the receipts from license taxes were gradually built up until in the year 1925 they amounted to $694,939.00, as compared with $509,007.00 in 1917 and $339,901.00 in 1919. These figures are for license taxes only and do not include the dividends from the Water Company.

The net earnings of the Louisville Water Company from 1917 to 1925 were as follows:

1917	$442,561.00	1922	$500,037.00
1918	432,323.00	1923	555,451.00
1919	422,552.00	1924	607,425.00
1920	440,265.00	1925	687,580.00
1921	470,231.00		

It is certain that when the Board of Water Works made its decision to divert a portion of the earnings of the Water Company to assist the Commissioners of the Sinking Fund, the future needs of the Water Company had not been forecast. During the war very little construction work was done and the accumulation has had to be taken

care of. Matters were made worse by a large increase in the population of the city, partly due to an increase in area of nearly fifty per cent in 1922, and partly to unprecedented growth due to other causes. The population of Louisville increased about five per cent during the decade between 1910 and 1920, when the Federal census showed 235,000. In December, 1925 a census taken under federal supervision fixed the population at 306,000, an increase of over thirty per cent.

The Louisville Water Company is now facing construction costs which will exceed $4,500,000.00 during the next five years, and that sum cannot be provided from earnings alone. Rates have been increased and it will be necessary to borrow money. The advance in rates has caused much dissatisfaction, although the increase is not heavy. If no dividend had ever been paid into the sinking fund the finances of the Water Company would be in a very healthy condition, it would not be necessary to borrow money and rates would merely have to be adjusted.

Although the idea of the dividend was a new one there was no open criticism until the rates were raised, effective January 1, 1926. At first the change was not well understood, but when the first bills were received there was a storm of protest. This was in the nature of open letters to the newspapers, letters to and personal calls upon the officers of the Water Company and one or two abortive mass meetings. The situation was not improved by adverse comment, editorial and otherwise, by a part of the daily press. The question was, why pay dividends to the city if the Water Company needed the money? Some business men of undeniable ability have held, from the first, that as the city had a large investment in the water property it was entitled to a fair return on its investment. The opposite view is that if the Water Company earns more money than is required for expansion the rate payers should benefit in reduced water bills.

It is not proposed to comment on the wisdom of the Board of Water Works in instituting the dividend. Opinion will vary with the point of view. It is, however, obvious that the question of diversion of the earnings of a municipally owned water works to other departments of the municipality should be considered with great caution. The practice may establish an embarrassing precedent.

J. E. Gibson:[4] We have tried to look at this thing from every angle but without regard to what approach we make, we always come back to the point that common honesty requires that all of the funds collected in payment of water and service rendered the consumer should be held inviolate and as a trust fund for the betterment of the service to the consumer.

The consumer is a rate payer without regard to whether he is a property holder or renter. The municipally owned plant is organized for the protection of the public and should be run without profit, for obviously it is an injustice to one portion of the public to make it pay a profit to other consumers or rate payers for a public service which should be rendered alike to all at equal cost. I know some argue that a renter or non-property holder pays no taxes and unless he is made to pay an indirect tax in higher price for the service rendered, he escapes. This is only to deceive themselves, and no one is worse deceived than the man who deceives himself. A non-property holder pays taxes just the same as the property holder. The only difference is that he pays them indirectly through rents, purchase of goods and other supplies used by himself and family while living in the community. Of course, some people will say that rented property does not pay, as the revenue is not sufficient to cover taxes, insurance, depreciation, and maintenance. In isolated cases this may be true, but it is a case where the investor has made a poor investment and his principal has shrunk due to conditions over which he or no one else had control. If we could all make investments with guarantee of no loss, there would be few bankruptcies in the world. The relation between the property holder in the city and the rate payer or consumer of a public utility, is the same as that of the banker and the borrower. The tax payer or property holder lends his credit only, and the rate payer or consumer becomes the borrower and should pay the interest, depreciation, maintenance, and operating costs for the service. When he has done this he has done all that he should, and any further payment is against the best thought of modern accounting. The day of bookkeeping as carried on by the crossroad mercantile house, where the members of the family helped themselves to whatever was required from the store without making an account therefor, is long past, and the same is true of the municipality. I maintain that all service given to the

[4] Manager and Engineer, Water Department, Charleston, S. C.

other departments of the city should be charged to and paid for by those departments, for service supplied without payment soon is abused and the benefits derived accepted without proper appreciation.

Fire hydrant service supplied to the community as a whole should be paid for by the community as a whole as it is of equal benefit to all. However, if given to the community by the Water Department without proper charge and payment, the property holder is receiving a service over and above the other rate payers, and the more expensive the property the greater the service rendered. This haphazard method of keeping municipal accounts reverts to the crossroad mercantile house, and I believe our courts and commissions are taking the proper step when they insist upon the funds of the utilities being kept inviolate. If the rates are too high, resulting in the accumulation of too large a surplus, then the rates should be reduced so as to give the rate payer the reduction direct.

The most recent case that I can recall is that of the Supreme Court of the State of Ohio enjoining the City of Cincinnati from increasing the rates of its water department, diverting the funds to fire and police departments and to schools. Cincinnati vs. Roettinger, 105 O.S., page 145 (Supreme Court of Ohio)).

Some years ago there was a very admirable paper presented before the New England Water Works Association by Mr. Burnham, giving a summary of statistics collected by him covering this subject. I have from time to time added to this and would be glad to furnish anyone who is interested with a copy.

George H. Fenkell:[5] A municipality should construct, operate and maintain a municipal water plant for furnishing a good and efficient service for the community, rather than to produce revenue to be used to finance other city activities.

In a decision of Uhler vs. The City of Olympia, vol. 87, p. 1, Washington State Report, the principles underlying the difference between a citizen tax payer and a citizen water consumer are discussed. The Supreme Court in this case, which was one affecting the debt limit of the city of Olympia, states that the charge for constructing, operating and maintaining the water works should be placed upon those who use water and not upon others; that the re-

[5] Superintendent and General Manager, Board of Water Commissioners, Detroit, Mich.

venues to be received from the water plant are not monies of the city; they do not partake of the character of general funds; that the object of municipal ownership is to give the citizens the best possible service at the least possible price; that the citizen who is taxed to the extent of his use of the utility is entitled to all benefits; that when the plant is maintained, the interest paid, and a sinking fund is provided for the bonds, the tax payer—the water user—who is primarily burdened with meeting the maintenance, betterments, interest and cost of the system, is entitled to the benefits.

From the above dictum of the above noted State Supreme Court, it is evident that the surplus earnings of a municipal water works belong to the water user, and that the surplus must be expended for improving the works so that these may be more efficiently operated, for extending the works so that a greater number of citizens may become water users and, if there is no such room for improvements and extension, it must be applied to a reduction of rates.

Where water funds are separated from other accounts, there is much less danger of diverting them to purposes other than those of a water works. There is a public knowledge, when these funds are kept separate, of their existence, and there is less danger of having some municipal body misapply these funds to other municipal operations. On the other hand, where water works funds are not segregated, but are mingled with funds raised by general taxation, the danger is at all times present that the water works' share will be used for purposes foreign to the water utility.

In Detroit, the Water Department serves a number of cities and villages adjacent to Detroit, and in the majority of these, there are no segregated funds against which water expenditures are charged, or to which water revenue is credited. Municipalities operating in such way at Detroit are often found on the list of delinquents. Because of pressing obligations of various kinds, the water receipts are used for purposes other than those for which these receipts were collected.

THE VALUE OF WATER WASTE SURVEYS IN ADDITION TO THE LOCATION OF LEAKS[1]

Edward S. Cole:[2] Much has been said in regard to the desirability of reducing the waste of water in distribution systems by locating leaks in the mains, services, etc., but I believe that half the value of a water waste survey lies in certain other items of information which can be secured only from such a study. I shall try to outline some of these incidental points of interest in support of my claim.

Checking maps and records. The average water works plant in a small town or city has been in operation for many years and in the early days methods of keeping records of what went into the ground were very crude. As a rule, these records were in the head of the superintendent who had possibly been employed on the construction of the plant, and who guarded them jealously because of the feeling that his value to the city or company depended on this knowledge.

In the course of a water waste survey from 75 to 100 per cent of the valves are operated and in this manner their location can be checked on the existing maps, as well as the size and location of the mains.

Condition of valve system. In addition to checking the location of the valves, their condition can also be noted and repairs made wherever necessary. In many cases the valves have not been operated for so long a period that many of them will not hold tight and some cannot be operated at all. In my opinion a valve that will not hold tight in an emergency is money wasted. It is, of course, of the utmost importance to keep the valve system at the highest degree of efficiency. The water waste survey emphasizes the need of periodical inspection and has been the means in many cases of inaugurating a definite program of inspection and repairs.

Closed valves. Another important feature of the survey is to discover if valves supposed to be open are open, and whether or not the valves on service boundaries supposed to be closed are closed.

Frequently we find valves on main feeders in the distribution

[1] Discussion before the Buffalo Convention, June 7, 1926.

[2] President, The Pitometer Company, New York, N. Y.

system closed with a resultant loss of pressure, in many cases creating a situation which would severely cripple the system in case of fire.

We recently completed a survey in a city in New York State with about 50,000 population, in the course of which we found a gate closed on a 20-inch main, which was one of the principal supply lines to the city. This condition was forcing a flow of water of over $2\frac{1}{4}$ million gallons a day, or approximately $6\frac{1}{2}$ feet per second through a 10-inch main. Later on we found a valve closed on another main feeder, and when these two valves were opened the pressure in the center of the city was increased by 20 pounds. The estimated cost of the cast iron main lying idle while these two gates were closed was $100,000.00.

In another city of New York State the system is divided into a high and low service, the low service being supplied by gravity and the supply of the high service pumped and filtered. The valves were supposed to be closed between these two services, but a water waste survey revealed the fact that a 6-inch boundary valve was open and about 400,000 gallons a day of costly pumped and filtered water was being discharged from the high into the low service. This amount was just as definite a loss to the city as if it had been escaping into a sewer from an underground leak.

Distribution of supply. The usual method of conducting a water waste survey is first to divide the distribution system into several districts and measuring the flow of water into each district for a period of not less than twenty-four hours. The information thus obtained is of the greatest value. It frequently discloses inadequacies in the gridiron system which can be remedied by laying reinforcing mains. These deficiencies are usually made evident by abnormal drops in pressures while the various districts are being isolated.

Engineers are very often employed by water companies and municipalities to redesign the distribution system to meet present needs and future requirements. The information secured from district measurements is of great value in a study of this kind, as it indicates the points of maximum consumption and also shows the maximum demand in each one of the various districts into which the city has been divided.

Trunk mains. In studying the waste conditions in larger systems it is usually necessary to test the trunk mains separately from the gridiron system by making simultaneous measurements at various

points, shutting off all laterals between these points. These measurements not only show the existence of underground leaks in the mains, but indicate those mains that are being overtaxed with a resultant loss of pressure in the areas they are supplying. They sometimes show that a large main supposed to be the principal supply to a certain section is in reality doing no work at all. These conditions frequently can be remedied by laying short cross connections or by valve operation, and if this is not possible the needed reinforcements can be designed to the best advantage.

C. C. BEHNEY: A number of engineers and water works superintendents have realized the possibilities for considerable savings and direct financial benefits and other advantages to be derived from water waste surveys. Few if any have been disappointed with the results obtained, and often the results have been beyond all expectations.

The writer has been in charge of a number of waste water surveys and judging from the results of these, it can be said that the annual savings as a result of the surveys were more than the costs of same.

Waste water surveys are not new, and much has been said and written on this subject, but anything which offers such benefits and such handsome returns on the investment bears repetition or elaboration.

Briefly summarized, a waste water survey properly conducted will accomplish the following:

1. Locate leaks with surprising accuracy
2. Locate wanton waste of water
3. Check large meters in place
4. Disclose unauthorized use of water
5. Check the pump slip
6. Give valuable engineering data
7. Check the condition of valves
8. Restore valve boxes to the street level
9. Check the condition of fire hydrants
10. Determine the distribution of flow to districts
11. Increase the pressure in the distribution system

A waste water survey:

Conserves the water supply
Postpones plant expansion
Saves interest on large invesements

Decreases waste
Increases distribution efficiency
Increases fire protection
Increases revenue

It is difficult to determine the value in dollars and cents of each of the several benefits and advantages just stated, and no doubt for this reason we usually think of the value of the waste and leakage which is recovered by a waste water survey. It is this factor more than any of the other benefits, which usually prompts action and leads to the making of a waste water survey. Likewise, it is for this reason no doubt that some are content to equip themselves with sound intensifiers and set out to search for leaks. Undoubtedly some leaks can be located by this procedure, but will you realize the most value for your efforts? Will you locate as much leakage by this procedure as by a comprehensive waste water survey, which furthermore gives many additional benefits? Sound intensifiers play a very useful function in locating leaks, but the value of first having an indication of an existing leak should not be lost sight of. This can readily be determined by measuring the flows to small subdivisions by means of a pitot tube. It enables one to know how much and where the water is going.

The amount of leakage that may be recovered in a system depends upon conditions and the nature of existing leaks and waste. It is not to be expected that all leakage and waste will be recovered. A perfect system would be able to account for 100 per cent of the water pumped or supplied. Some systems account for 90 per cent or better. That is, the leakage and waste are less than 10 per cent. If this can be accomplished in some systems, it is reasonable to expect that like results can be obtained in similar systems.

After a waste water survey the Syracuse Suburban Water Company was able to account for about 95 per cent of the supply.

After a survey at Lexington, Ky., they could account for about 90 per cent of the water pumped. The leakage recovered amounted to 17½ per cent of the water pumped.

At Hagerstown, Md., a waste water survey brought the per capita consumption down to 38 gallons per day exclusive of the industrial consumption. Accordingly 38 gallons per day per capita represented the domestic consumption and included whatever leakage and waste that may have remained unrecovered. The leakage recovered amounted to about 16 per cent of the total supply. The yearly

saving in electric power at the pumping station exceeded the cost of the survey. This was a gravity system and the only pumpage was that of a booster pump.

In the City of Syracuse, N. Y., a survey recovered 4,000,000 gallons per day, or about 15 per cent of the total supply.

D. A. HEFFERNAN:[3] I am a great believer in the water waste survey. In 1890, before this work was done as commonly as it is now, we had our own method of determining the location of leaks in our system in Milton, Mass. This method, while considered old-fashioned, was entirely practical and still is today. The method we used was by means of test pits. By this I mean that a tap was made either side of a valve in the main line of a distribution system. These pits are conveniently located in various parts of the system so that, by operation of gates, the system may be divided into a number of parts. When in actual use the taps are connected together through a 2-inch meter forming a by-pass around the main valve, which is closed.

Only six months ago we had a bad leak which increased our consumption about 30 per cent. We discovered the presence of the leak through reading of the master meter. Upon discovering that there was a leak in the system we divided the town into four sections, on paper, and starting out at midnight we cut off one section after the other until we discovered that the leak was in the last section to be tested. After locating the leak roughly we moved our testing apparatus to a pit in the section in which the leak was and from this location we were able to confine it to an intersection of four streets. The geophone brought us to within 6 inches of the actual break which was in a 6-inch main within a few inches of a sewer manhole.

The main at this point had rested on a rock and I suppose that the heavy trucking which the street carried had caused the pipe to settle, breaking the pipe clean. The break, occurring so close to the manhole accounted for the fact that no sign of the leak showed on the surface of the street. As I have said, the road at this point carries a considerable amount of traffic at all hours of the night and as it did not appear feasible to divert the traffic, we used the geophone by getting down on our knees and throwing a blanket over us covering ourselves and the geophone entirely, tending to exclude foreign noises. After making the simple repair our consumption went back to normal and, by the way, has remained there since.

We are 100 per cent metered and have been since 1890 and we are able to account for about 85 per cent of our water. We do not allow for slippage of meters in computing our accounted for water and I would like to take the opportunity to ask Mr. Behney if slippage was allowed for in his computation of accounted for water.

C. C. Behney: Yes, it was allowed because the water was measured by a meter.

D. D. Heffernan:[3] The usual practice, I think, will allow two or three per cent variation for the slippage of meters.

C. C. Behney: I mean there was no allowance made, but the meter actually measured actual pumpage.

D. D. Heffernan: I have mentioned these facts because I am proud of my system. We have 60 odd miles of pipe in a town of 13,000 people. In order to keep the consumption down to 600,000 gallons per day and per capita consumption at 45 to 47 gallons per day, the system has to be pretty tight and the reason for having such good results in our case is due to the fact that we do our own work, lay our mains and services from main to meter. I have given thirty-six years to my little system and I hope my pride in it may be pardoned.

Wm. A. McCaffrey:[4] A leak of 125,000 gallons a day is a very small one. Here in 1918 we thought we might have a survey. There was no leak showing above ground whatever, and we knew that we had no leak underground. The former superintendent had made a recommendation to put in another eight million gallon pump, but finally we had it surveyed and we found one twenty-inch main, that had a leak of 150,000 gallons a day. We found in a 6-inch main going into a boiler shop, a leakage of 345,000 gallons, in another main a leakage of 70,000 gallons a day and in another main 500,000 gallons of water being used and not being paid for; that was in a starch factory. The owner of the starch factory years ago owned the water works.

[3] Superintendent, Water Department, Fulton, Mass.
[4] Superintendent, Water Works, Oswego, N. Y.

Chairman Gensheimer: Was that a leak?

Wm. A. McCaffrey:[4] No, that was not a leak, that was use, but the present owner knew nothing about it, so he said. When we got through with those leaks, we decided that we did not require a new pump, but I think now that within the next year or so we will have another survey in order to find the small leaks.

Mr. Pierce: This applies to us small fellows as well as you big fellows, and it does produce some surprising results. For instance, one night we were trying to isolate a section to start work. We attempted to close one valve, but we could not find the stem to put the key on, so we let that go. The next morning we asked the foreman who had been on the job some twenty odd years, what he knew about it. He did not know much about that valve except that there was one there. He remembered some fifteen years previously that they had tried to turn the valve and had broken the stem. They had taken the gate and stem out, but did not have another to put back, so they put a wooden plug in and forgot all about it. We tried to convince the superintendent that leaks were below the surface and did not appear on the surface. We were able to find a leak going into a sewer. A nearby house had complained about a noise on the pipe, but when the leak was repaired, the noise stopped. In another case we found that at certain hours in the day there was a reversal of flow. Those of you who are interested in checking your pumps may refer to the December, 1923, issue of Engineering and Contracting, where there appeared a short article describing the method to be followed in pump slippage.

Mr. Patten: What is the usual practice in figuring per capita consumption?

Wm. A. McCaffrey:[4] A great many take the total consumption on the total pumpage and divide by the population.

Mr. Patten: The objection to that is that some towns have a very large industrial sale of water. Other plants have almost no sale to the large industries. Consequently you have not a reliable guide, I think, in figuring per capita consumption, where you are not stating that you previously deducted the sale to industrial consumers. This

ought always to be deducted. The water that is sold to factories by meter should be taken from the total pumpage and then with the estimated population you will get the per capita consumption.

Mr. Pierce: In the back part of the Manual of Water Works Practice there is a form suggested to be filled out for different water works statistics, and in that it describes how to figure the per capita. I believe that includes everything. The estimated number of people served, not the estimated population of the city, is used.

E. S. Cole:[2] In The Journal for March, 1915, will be found the report of a committee on Water Consumption of which the speaker was chairman. This report contains a chart showing the gross per capita consumption of 133 cities. Two shaded areas represent the metered domestic use and the metered non-domestic use respectively. The importance of segregating industrial from domestic use is thus clearly brought out and it would seem that the per capita rate, *after excluding industrial consumption*, is the only safe criterion of use or waste by which we may compare one city with another.

Mr. McDowell: In connection with the computation of consumption per capita, I can recall one case, that of a town using about 5 million gallons of water for domestic use, where the industrial use in one plant ran up to 72,000,000 gallons a day. That would be very misleading if they did not exclude the use for industrial purposes. In connection with the water waste survey, some little experience I had in detecting a reversal of flow might be interesting. We had one block in the city that was continually complaining about red water. In that street one of the earlier mains was laid. I went down there for the purpose of really determining the pipe coefficient preparatory to cleaning it, and in installing the pitometer I found a reversal of flow before I got all my valves shut down. That probably was the reason of these complaints. I suggested that we deadhead one end of the line, which we did, and we had no further complaints from that source for about two years, when we replaced the line with cement-lined pipe. There was another case where I was trying to confine the water to a certain district, in order to measure the flow, and I got it down to about fifty thousand gallons in one block. It was near the edge of the harbor, where it was pretty

difficult to locate a leak exactly, but before completing the investigation, we did find a leak in the main that was discharging into a sewer. It revealed itself.

L. S. Spire:[5] In the city of Buffalo, for the eleven months of the present fiscal year ending May 31, this year, our increase in consumption amounts to about two hundred million gallons. Our increase in industrial use is increased about four hundred and fifty million gallons. Now we are going to show an increase in pumping, but still we show an increase in industrial use. I was amused to hear Mr. McCaffrey speak about the pitometer survey in Oswego. The Pitometer Company made a survey here, starting July 1, 1917, and spent two years here. I would like to mention two instances of leaks found. One was in the rock section of the city, near the quarries. The pitometer showed in this sub-division, in between two valves in one block—and, by the way, there are no connections off of this sixteen inch main—a flow of 250,000 gallons. On investigation we found a beautiful drinking place built in this quarry with a nice, shiny dipper. The watchman that night said: "We have a nice spring here; for several years it has been going so fast that we have to have an electric pump to pump it out." Again, I discovered a break in a sixteen inch main. In another instance, in a park we have a quarry and I found water flowing in there. I shut the main off and the water stopped. A man had been coming down there with a huge bottle for this spring water and he was keeping it a secret. Afterwards he had to go elsewhere for his spring water.

Buffalo is about 15 per cent metered, so you can see the enormous house waste we have. The industrial use in the city is about 33 per cent of our total pumpage. Last year inspectors were sent throughout the district, and we had it measured for the entire year, or rather about ten months of the year. They reported approximately 27,000 fixture leaks and about 2000 service leaks.

H. P. Bohmann:[6] Per capita consumption does not mean anything. Buffalo supplies a population of 550,000. The year I made a comparison with the city of Milwaukee, you were serving the same population we did. I found that you were using as much water thirty years ago as we are using at the present time, so that proves

[5] Chief Pitometer Operator, Bureau of Water, Buffalo, N. Y.

[6] Superintendent, Water Works, Milwaukee, Wis.

that per capita does not mean anything. Previous to 1912, no effort was made to account for the water that we were pumping, but since 1912 an effort was made to secure this information each year.

Henry T. Gidley:[7] You might be interested in a leak we found in our town. The owner of a garage on Main Street called me up one day and told me that he had been having trouble with water in his boiler pit. It would rise up and threaten to put out his fire. He said that it had been running for three weeks, and it got so bad that he had to install a gasoline pump to take care of it, and the water was so clear that he thought it might come from our system. We went over to make an investigation and told the man to shut off the service on that line. There were two boxes outside, and when I went out to see, he had shut off the wrong box, or started to, and I told him that was an abandoned service. "Well," he said, "that service was turned on full." When that was shut off the water ceased immediately. I made some inquiries about the garage, and it seems that three weeks previously, on a Sunday afternoon, some one had broken off the gas pipe left inside the door to the garage. They sent for the gas company and the superintendent of the pipe department came over. Although our box was marked water very plainly, right in front of the door, he put his stock wrench on it and turned on the water. He did not seem to stop the gas, so he finally plugged the pipe inside and went away without saying anything. I thought that probably the stream from this old service would run about the size of a half inch stream, so I put a meter on our meter tester and ran it for a little while to see about how much it would run in three weeks, and sent a bill to the gas company. The treasurer of the gas company, whom I have known for quite a number of years, was quite put out about it, and wanted me to step in and see him about it. In the meantime his superintendent had been over to see me and wanted to know about it. He said he turned it on but it was an accident. Finally I saw Mr. Price and talked it over with him. He finally settled the bill and I do not think they will turn on a water pipe again.

Elon P. Stewart:[8] In Syracuse we have been carrying on water waste surveys with our own forces for over two years. We have received all the benefits mentioned by Mr. Gidley and Mr. Cole in

[7] Superintendent, Fairhaven Water Company, Fairhaven, Mass.
[8] Engineer, Water Waste Survey, Bureau of Water, Syracuse, N. Y.

making such surveys. Our water does not have to be pumped, it runs by gravity, but there is one thing that means dollars and cents that I want to call to your attention. There has not been much said on this tonight, and that is on the question of checking large meters. I found one meter, one of the largest in the city, about 50 per cent slow, which was quite an item in itself. It is not uncommon for me to find them 10 or 20 per cent slow, or any ordinary amount of that kind. A small water district near Syracuse engaged me a short time ago to find out why they had so much unaccounted for water. They were determined that somebody was stealing it. On checking it up, I found that their master meter was about 40 per cent fast, and on taking it apart, it was a turbine type, we found it all clogged up with moss and stones. It was cleaned out and the trouble was over and they were satisfied.

A Member: I would like to ask Mr. Stewart if they furnished the water for that master meter?

Elon P. Stewart[8]: No, they turbined it from a neighboring village.

Mr. Patten: For the last four or five years we have been buying nearly all our meters from one company. We kept getting so many complaints about the large bills, that I took one of these meters out and tested it. Nearly every one of them that I tested was 5 per cent fast. They are all tested when they reach our shop, and they are approximately accurate, say within 1 per cent, but after they have been in service for six months, they get 5 per cent fast. I cannot account for it. I do not see how a meter can get fast.

A Member: What is your pressure?

Mr. Patten: Eighty-five pounds. I can see how a meter can get slow, but not how it can get fast.

A Member: Any corrosion?

Mr. Patten: No corrosion whatever. The explanation of the meter company's representative is that the meters probably were not sensitive enough when they left the factory and after they had been in service a little while, they became more sensitive.

Mr. McDowell: I would like to ask Mr. Stewart whether they were all turbine meters he found fast?

E. P. Stewart:[8] The one I found fast was a compound meter; the slow one was a turbine meter. I found almost every type slow, but the fast one was a turbine type. I have asked our chief meter repairman what had been his thirty years' experience in repairing meters and finding them fast. He said that in the turbine type it was quite common to find them fast from clogging up with moss and that he had found meters fast of the disc type when there was a little coating of oil or grease on the disc. How often that occurs, I do not know, but he said that he had actually tested them and found that condition.

Mr. Taylor, of New Brunswick: We sometimes find a disc meter fast. Our water carries a little vegetable matter in suspension and that sometimes forms on the inside of the measuring chamber, which of course reduces the size of it. They will run as high as 4 or 5 per cent fast, but that is after a considerable time, when they have had time to accumulate a lining on the inside. Sometimes I think the difference in the pressure where they are tested and where they are put in service makes a difference too. For instance, we test at 85 pounds pressure, and if a meter is put in under 20 pounds pressure, you might not get the same results.

UNDERGROUND WATERS AND PUMPING THEREFROM[1]

By George W. Trauger[2]

My residence in California for almost eighteen years, and particularly in Tulare County, where there are in excess of twenty thousand acres planted to citrus groves, irrigated exclusively from underground waters with which I am familiar, and my connection with the Lindsay Strathmore Irrigation District since its organization on November 9, 1915, first as field engineer and for the past eight years as Superintendent and Manager, has given me some knowledge of the subject of underground waters. The Lindsay Strathmore Irrigation District has been an object of interest to engineers, lawyers, and water users generally, for the past ten years, by reason of protracted litigation involving its water rights. I wish to apologize to the learned members of the bar who may be present, for placing engineers ahead of them, but I believe in this particular instance we engineers started something, and we now pray that the lawyers will finish it. Believing that my connection with the Lindsay District is the primary reason for my selection to discuss this subject, and also because this District is vitally concerned in underground waters and pumping therefrom, I am going to review the history of it.

The Lindsay Strathmore Irrigation District was organized on November 9, 1915, under the "Irrigation District Act of the State of California." It extends from the Southern Pacific Railroad on the west, eastward to the westerly slope of the Sierra Nevada Mountains, and from a point three miles north of the Town of Lindsay, Southward to Strathmore. Its boundaries are irregular. Its gross area is slightly over 15,000 acres. The district lies wholly within Tulare County. Prior to the year 1900 the land now within the district was used either for dry farming or allowed to be fallow. By 1903, five hundred acres of the area had been planted to orange trees, many of which were in bearing. These plantings showed that valuable citrus crops could be produced by irrigation with water pumped

[1] Presented before the California Section meeting, October 29, 1926.

[2] Superintendent, Lindsay-Strathmore Irrigation District, Lindsay, Calif.

from underground sources. As a consequence, the development from 1903 to about 1914 or 1915 was rapid, and by the end of 1914, over 7000 acres had been planted to citrus crops. Of these about 6000 acres were in full bearing. Practically all of the San Joaquin Valley is semi-arid, in the sense that irrigation is necessary to profitable production and this is particularly true of that portion of the Valley now known as the Lindsay District. The increased draft on the water sources to serve this additional planting, so lowered the water table that the supply showed evidences of depletion as early as 1912 or 1913, and by 1915 the water supply had given out entirely in some areas, and in others it had become so salty that its use for irrigation purposes became injurious, if not absolutely destructive of the crops and trees to which it was applied.

It therefore became necessary for the land owners to acquire other water sources from which a sufficient supply could be obtained. Otherwise the area about Lindsay would revert to desert conditions of earlier days. About ten miles north of the Town of Lindsay there was found a tract of land lying on both sides of the Kaweah River, known as the Rancho de Kaweah, and consisting of course sand and gravel filled to the surface with water. Opinions of competent engineers were obtained to the effect that sufficient water to supply the needs of the citrus groves in and about Lindsay could be obtained by pumping from this underground basin, and relying thereon, the Lindsay Strathmore Irrigation District was organized in 1915; the Rancho de Kaweah was purchased; and thereafter thirty-nine wells, spaced at one-eighth of a mile apart, were bored, and are now, and have been since the year 1918, pumped and the water obtained thereby transported to the lands within the Lindsay District.

About 12,000 acres of citrus orchards to the west of the Southern Pacific Railroad remained out of the district, feeling that their supply was ample and would hold out with the discontinuance of pumping on the East. About 500 acres located inside the district boundaries also decided to take a chance on their wells in preference to coming in. Practically all of these last mentioned lands exhausted their supply in a few years and have since been taken into the district. This was done by buying unimproved lands within the district and thereafter excluding them and substituting the improved lands in their place. This entire project was approved by the State Engineer, and by several very well known engineering firms; bonds of the district were approved by the State Bond Commission, and

were sold at or very near par. The outstanding bonds consist of two issues: the first issue in the amount of $1,400,000 sold at a premium; and the second issue of $250,000 sold at slightly below par.

The history of our water conditions is similar to that of many other parts of California. The area west of the Southern Pacific Railroad, before mentioned, is now finding that it also has a water problem. Its supply is greatly depleted; many wells have become salty; the water table has been lowered beyond an economic lift. This is due to several causes. First, many sections have developed by the use of underground waters, without any study of the amount available and the possibility of replenishment. It should be the purpose of men who develop projects of this character to prevent over-drafts on underground basins. This is done by our state where districts are formed, but I have in mind cases where an individual will drill a well, get water and profitably raise crops; then another comes in, and does likewise. Some real estate company buys large tracts, sub-divides the same and sells to innocent purchasers on the strength of what this or that man has done. In the course of a few years there is no adequate supply and failure for many is the result. I favor either a state or even a county control of drilling wells. This may be impossible. There certainly should, however, be some control of men drilling wells in order to protect the public. Enough money has no doubt been wasted by poor well drilling, poor equipment and unscientific methods, to build many good storage reservoirs. Many of these men do not even know how to keep a log of a well. I have known many cases where a rancher has drilled a well, usually for convenience, near his property line, sufficient for his needs; then his neighbor drills just across the line; then they play hide-and-seek with each other until one "goes broke." I know whereof I speak. I have lived on an orange grove, and still do, and have seen this very thing happen many times. The State keeps tab on the drilling of oil wells; why not on water wells?

Secondly, there must be a greater effort made to conserve our water in times of heavy run-off, both by building reservoirs, and when these are full by spreading as much as possible to build up the underground storage. This means a study of the underground basins and means of replenishment. The great advantage of underground storage is not fully appreciated. In our own case, the past three years have amply demonstrated that where it is possible this is the best storage. We were able to meet our needs in a fairly

satisfactory manner, when almost any other plan would have left us "high and dry." In many cases the underground storage basin is filled by fall and winter flows that otherwise would be lost, leaving available for spring and early summer irrigation a greater amount of water. For this reason a better study should be made and a systematic way worked out for the filling of these basins.

A condition that is true of the Kaweah River is also true of many other streams of California. This river, with a water-shed of about 600 square miles, rises at the top of the westerly slope of the Sierra Nevada Mountains at an elevation of 10,000 to 12,000 feet. This stream with its tributaries has an annual run-off of about 450,000 acre feet. From 1915-1916 to 1925-1926 the average run-off was 295,000 acre feet. From 1906-1907 to 1915-1916 it was 458,700. This is 1,550,000 acre feet less than normal for the past ten years. These figures, which do not take into consideration the big year of 1905-1906, account in a large measure for the present acute condition.

An underground reservoir will store and hold water, especially where there are often early fall rains which bring up the flow of the rivers, and heavy floods during the winter and spring. These fall and winter flows will replenish the basin, in most cases, before the water is needed in the regular irrigation period. A well on the Rancho de Kaweah is at an elevation of 411 feet, about 10 feet higher than flood level of the river, and never according to our records subject to overflow. It is in an area where about 14,000 acre feet has been pumped out each year for the past eight years. It gives a good idea of how water can be stored, used and replenished. On April 3, 1918, before any pumping had been done in this area, there being no wells closer than two miles or more, the water in this well was 11.5 feet from the surface. On April 29, 1926, the water was only 14.9 feet from the surface. It must be remembered that in this section of the San Joaquin Valley, the years 1924, 1925 and 1926 were very dry, but with all this pumping and dry years, we only have a loss in ground water elevation of 3.4 feet.

On the same well the draw-downs over a period of a year were taken each month during 1921, a normal year in rainfall, snowfall and run-off. On April 4, 1921, the depth to ground water was 12.3 feet; by May 2, 1921 it was 16.8 feet; on June 1 it had come back to 14.4 feet, due to flood waters from melting snow, the river over-flowing its banks. By November 2 it had reached its lowest point, 23.5 feet, and by April 7, 1922, it was back to 13.7 feet, and on May 4,

1922, it was 12.6 feet, or only 0.3 of a foot lower than the previous year. Many of these areas that are pumped have been greatly benefited by holding the ground waters below the root area of the growing crops and in many districts pumping is absolutely necessary to keep the ground from becoming water logged.

At this point I wish to tell of the owners of 60 acres of orange orchard, who came in one day to find out if we would install a meter for them. They were part owners in a large well; the water was not measured and they felt they were not getting sufficient for their needs, or in fact their share of the water. I found out, before getting through with them, that at the time they were planning to buy drainage pipe to draw off water, and that even the water they were getting was just twice what they needed for an orange grove, located as theirs was on very heavy soil. I had to show them some mighty fine groves, with a metered system, using the needed amount, to convince them. Which only goes to prove, as I believe, that in many cases ground waters are being used far beyond reasonable requirements, and in many cases to the actual injury of crops.

A short review of the history of the litigation in which the Lindsay Strathmore Irrigation District is involved may be of interest. Furthermore, the effect of its final outcome upon our District may be of vital importance to other districts and municipalities. The original complaint was filed on July 15, 1916. Included among the plaintiffs were one irrigation district, 17 mutual water companies, and 56 individuals. The purpose of the action was to enjoin the Lindsay Strathmore Irrigation District from pumping water on the Rancho de Kaweah, and conveying it to lands within its boundaries for irrigation and domestic use. Briefly stated, the complaint alleged: That the underground water body in the Rancho de Kaweah is a part of the Kaweah River; that the defendant has no right to take any of the surface water of the river; nor any right to reduce the flow of the Kaweah River as the same passes over the Rancho, by lowering this underground body of water which, it was alleged, supported the surface flow. The stand of the defendant, briefly, was: That there was and is a surplus of water over and above the reasonable needs of all the plaintiffs, allowing for ditch seepage and the thorough irrigation of approximately 100,000 acres shown to have been irrigated. All of the principles of law applicable to water and the use thereof were involved in this case. The plaintiffs included in their number riparian owners, overlying land owners and

appropriators from natural streams. The right of ditch owners to water lost by seepage from the ditches; the right of overlying land owners to underground waters built up by natural streams; the rights of riparian owners as affected by the "Water Commission Act of 1913," were argued and considered. I should know considerable on this subject after ten years of litigation, and the study of a collection of field data that treats on it from every angle. As a result, only one thought is uppermost in my mind: it is that underground water is and will be for many years to come an important factor in making possible the irrigation of large areas in California.

The complaint was filed July, 1916, and the trial began October, 1917, before Judge Wallace in the Superior Court of Tulare County. It closed after sixteen days of argument, in May, 1919. The Court gave its opinion in favor of the plaintiffs in July, 1919. The Supreme Court of the State was asked for a Writ of Prohibition, to prevent the entry of a judgment in accordance with the opinion, on grounds that the Judge was an interested party, he having a small lot underlaid with the same body of water that the dispute was about. The writ was granted, and all proceedings to that date were declared invalid. Judge Jones of Nevada was called in, and he made an order requesting the Governor to appoint a Judge outside the County to hear the case. Judge Kinsell of Oakland was appointed, was taken ill after hearing a few motions, and resigned. Then the Hon. Peter J. Shields of Sacramento was appointed, but on account of pressing business in his court, could not serve. Then Judge William M. Finch was appointed and accepted. The trial of the case proceeded before him for about four weeks, when he was offered a seat on the District Court of Appeals, Third Appellate District. This he accepted and withdrew from the case. During Judge Finch's stay on the bench, he repeatedly urged a compromise and even said the means were not lacking whereby this could be done. Judge Seawell of Oakland was then appointed and accepted, but after a brief stay found that his wife had relatives that had land in our district, and retired. Judge Albert Lee Stephens of Los Angeles was next appointed and accepted the task of trying the case. After almost two years delay, the case opened November, 1921, with Judge Stephens presiding. The trial closed July 31, 1923. Final arguments were made in Los Angeles in December, 1923. Judge Stephens issued a memorandum opinion in May, 1924. Findings of fact and conclusions of law were filed in May, 1925, ordering the issuance

of a perpetual injunction against the Lindsay Strathmore Irrigation District. In April, 1926 the judgment was filed, and concurrently therewith an order suspending the operation of the injunction, on terms, pending an appeal to the Supreme Court which the Lindsay District announced it would take. At the time the findings were filed in May, 1925, the attorneys for the district made a motion for an order suspending the injunction pending the appeal. Judge Stephens made an informal announcement that he would grant the motion. The plaintiffs then asked the Supreme Court for a Writ of Prohibition to prevent the entry of such order. This matter was argued before the Supreme Court En Bank at Los Angeles. That court three months later denied the writ.

The case is now in the Supreme Court on appeal. The record on appeal consists of 25,000 pages of transcript, over 700 exhibits and the judgment roll, which comprises 900 printed pages. The cost has been, including both sides, close to a million dollars. There has been some criticism of the length of this trial, but I wish to say to this convention, that our people are very grateful that we have been able to hold the water during this period. We have had an opportunity to strengthen our position during the past two years, by the acquisition of water stock in mutual water companies and corporations diverting water from the Kaweah River. This water stock represents an amount of water in acre feet, 50 per cent greater than any amount pumped in any one year by our District, and we are now devising ways and means of using this water, if our appeal to the Supreme Court is not successful.

The Lindsay District has one of the most modern irrigating systems which is based on a high duty of water. Thirty-nine pumping plants are located on the Rancho de Kaweah; about 20 miles of redwood pipe, 14 to 48 inches in diameter, lead from the Rancho to a low line cemented canal, 6 miles long; this canal conveys the water to the main pumping station, three miles north of Lindsay. The total lift at the Rancho is about 120 feet to the main pumping station; there it is boosted 162 feet to a gunite bench flume 6 miles in length. From this flume the water is taken out and distributed over the district by means of 100 miles of riveted steel pipe, varying in diameter from 4 to 36 inches, and is delivered to the consumers under pressures varying from 0 to 75 pounds. The same supply is used for both domestic and irrigation purposes. At the end of the bench flume, two steel lines lead off, one 30 and another 36 inches in

diameter. The first 4 miles in length supply a second small booster station where another lift of 160 feet is made to serve 2000 acres on a higher elevation. At this last lift the water is placed in a small cement canal 3 miles long and is distributed therefrom by steel lines. The system if 100 per cent metered, with loss from all sources of about 4 per cent. This includes the loss by metering as a whole at the source and distributing in small amounts. Our people like the meter system, and I am a firm believer that, where individuals own their own plants, the water should be metered, so that they can tell the amount used and have some idea that the application of water is near the amount needed for the crops being raised. The irrigation rate is $10.00 per acre foot and the domestic rate $20.00 per acre foot. This money is used on operation only, while bond interest and general funds are paid from direct taxes on all lands, the rate being the same on improved and unimproved lands. The average cost of water per acre which includes everything, including litigation, is about $26.00 per acre.

The balancing feature is taken care of by a small reservoir holding 20 acre feet, located about one quarter mile beyond the last pumping station, and 25 feet higher. The pumps are connected with the line going to the reservoir, and the surplus, if any, goes by. If a shortage exists the same line carries the water back.

The irrigation season normally is about 210 days, depending greatly on the rainfall, and water use is based on a high duty and economic handling. The duty is about 1.6 acre feet per year. A certain amount is allowed per acre each thirty day period, and the consumer is usually permitted to take the same in heads as needed. Very few services take as high as 35 inch heads, the average being about 15 inches. Our connected electric load is 3750 h.p., yearly use over 10,000,000 k.w.h., and the rate is about 0.8 of a cent per k.w.h. and voltage on all motors 2200.

The experience of the last ten years with the affairs of the Lindsay Strathmore District has caused me to form the opinion that no more dependable supply of water for irrigation purposes can be obtained than that from underground basins. Nature has created many such natural reservoirs in California, of which that tapped by the Lindsay District is probably the best. The rains of the fall and winter, and the snow flow of the spring and early summer, are rapidly absorbed and as rapidly extracted by the pumps. The rate of underground lateral percolation is so slow—about 6 feet a day—that little

water escapes. In a climate where evaporation from water surfaces is so great, from 5 to 7 feet per annum, the storing of water underground completely salvages this loss, provided the water table in the sands and gravels is not less than four feet below the surface. In my opinion the most economical method of conserving water is to take advantage of these natural storage basins, and, by causing the surface flow of the streams to pass over wider areas, to increase the absorption thereby. No more economical and permanent source of supply can be obtained.

WATER SHORTAGE IN INDIANA[1]

By Lewis S. Finch[2]

A discussion of water shortage in Indiana is of particular interest at this time, since the dry weather during the past spring and summer caused shortages at places where this difficulty had never been experienced before.

The public water supplies of Indiana are obtained from shallow and deep driven wells, dug wells, streams, natural and impounded lakes, and springs. As would be expected the supply of water from impounded surface sources is subject to the greatest seasonal fluctuation with regard to quantity, although the ground water supplies are also subject to serious shortages, due principally to a lowering of the ground water level.

The semi-public and private water supplies are drawn mostly from dug and shallow driven wells and cisterns. Usually these private and semi-public supplies are the first to suffer a water shortage, but, since in each individual case a comparatively small number of people is involved, I shall not touch upon this phase of water shortage except in one case. In that instance, the shortage of water on one man's farm seriously involved a public water supply and endangered the health of about 5000 people. This man raised hogs and due to the dry season, the pond from which the hogs drank, and in which they wallowed, dried up. It then occurred to this farmer that a water main ran across his farm, and that at one time a tap had been made on this main. What could be simpler than to find this tap and permit enough water to run out of the main to provide a pond for the hogs. Of course, anything taken from a public utility is not stealing, so he at once acted. On the very top of a hill he found the tap buried, and very conveniently for him, a valve had been left on the pipe. He cracked this valve and then covered up the connection, and went his way. Soon, on the top of this hill, a pond appeared, and the hogs found it a most wonderful place.

[1] Presented before the Indiana Section meeting, March 26, 1926.

[2] Director, Water and Sewage Department, State Board of Health, Indianapolis, Ind.

So far so good, and if one important factor had not been overlooked no harm, except the loss of the water, would have resulted. But the water main happened to be under a very low pressure, 18 to 20 pounds perhaps, it being a low pressure main from the wells to a booster pump. The hill on which the pond had been created, also just happened to be high enough that when the booster pump was pulling hard, a negative head developed at the point where this valve had been cracked. When this negative head developed, the hogs were somewhat discommoded for the pond almost disappeared.

About that time, a sample of this city water was submitted to the Water and Sewage Department for examination. It was found to be contaminated, as were several other subsequent samples. Several investigations were made, and finally this pond was discovered, the connection closed, the mains flushed, and all was well. The matter was not made public, no one was excited, and luckily no sickness resulted.

In the case of public water supplies I shall bring to your attention, somewhat in detail, only those cases in which the health, as well as the wealth of a community are involved.

By so limiting the scope of this paper, I do not wish to belittle the effect of inadequate fire protection upon the growth and industrial expansion of a city or town. No place can hope to reach its ultimate development industrially or socially, until adequate fire protection is provided at all times.

The water shortages that occur in a number of cases are due to a city outgrowing its water supply. What originally could be considered an adequate supply, becomes pitifully inadequate when the city doubles in size. In these cases, it sometimes takes a severe jolt to bring the "powers that be" to a realization that their city has outgrown its water supply and that money must be spent to make the supply meet the demand. A shortage also often exists because of the fact that a populace demands that an inadequate ground water supply be utilized in preference to a treated surface supply, since they think that they do not want any chemicals added to the water that they drink.

Other places, lacking even an adequate surface water supply, face the necessity of coping with a falling ground water level. Table 1, prepared some years ago by Mr. Brossman, and which I am using with his permission, clearly shows how the ground water level has fallen in several individual wells, in a surprisingly short time. These

figures are given, not to show actually what is happening at present, but to indicate the trend of ground water levels in many wells. No doubt comparable figures could be given showing the same or greater drop in recent years.

It should be noted that since this table was originally prepared by Mr. Brossman, Muncie has given up trying to get sufficient water from wells and has installed a plant to treat the White River water.

In other cases, where water from a natural or artificial lake is used, a long dry season creates a situation that renders drastic steps necessary. In such cases, an emergency supply is brought into use that more often than not is of such quality that the existing means of

TABLE 1

TOWN	DROP OF WATER LEVELS IN SOME WELLS	LENGTH OF TIME FOR DROP TO OCCUR
	feet	*years*
Kentland	48	5
Elwood	40	12
Greensburg	40	10
Muncie	28	Not given
Remington	8	10
Marion	6	20
Butler	4	10
Bourbon	3	8½
Linton	30	6
Kokomo	15	15

treatment cannot render it potable. It is only the grace of God that prevents a severe outbreak of typhoid or other intestinal disturbance.

Such a situation existed during the past summer at Huntingburg. Huntingburg ordinarily draws its public water supply from two artificial lakes. This supply at best can in no way be regarded as satisfactory for drinking purposes, since the only treatment which it receives is the natural sedimentation that occurs during the storage in the lakes. Due to an unprecedented shortage of rainfall on the watershed of these lakes, they became dry, or practically so, early in June. All industries in the town were shut down until a temporary pipe line could be laid to the Patoka River, several miles away. The people were warned of the condition of the water that was in the

mains and in general private supplies were used until late in the fall, when sufficient water had accumulated in the lakes.

It is stated that no serious outbreak of typhoid occurred during this period, but immediately after the emergency supply was discontinued, and the lake water again turned into the mains, an outbreak of a peculiar type of intestinal "flu" occurred. It cannot be said conclusively that this trouble came from the water, but the indications point that way, since the outbreak seems to have been confined to the town itself. This can only be considered a coincidence, since no actual investigation that would conclusively point to the water was made.

In this situation at Huntingburg another means of endangering the public health, through a water shortage, should be noted. In this case, as in others, the first step that the people took after being notified to boil the water, was to begin utilizing private wells of doubtful quality. A survey of the private wells was made by the health officer and a majority were found to be unsatisfactory. This is usually the case in built up sections.

Of the large cities in Indiana, Fort Wayne suffers the greatest water shortage. The water supply there is drawn from approximately 50 wells, from 6 to 10 inches in diameter and from 250 to 1200 feet deep. During the past summer, there were times when to conserve a sufficient supply of water in the reservoir, for an emergency, it was necessary to leave parts of the city virtually without water. Since that time, one additional well of the Layne and Bowler type, has been completed, and another is under construction. The contractor has guaranteed a flow of 2,000,000 gallons from these wells. It remains to be seen, however, whether these wells will relieve the situation.

At Richmond, last summer, a shortage occurred that involved almost every type of water supply that has been developed in Indiana. Richmond impounds the water from springs and draws water from wells and infiltration galleries. To relieve the situation, water from a small creek was pumped into the mains. Since the supply at Richmond is chlorinated, and great care was taken at that time that the dosage meet the varying conditions, no unsatisfactory samples of water were received by the Water and Sewage Department. Nevertheless as an added precaution, the people were warned to boil the water.

Another situation exists, in several cities in the state, that con-

stitutes a potential danger to the health of the residents. In these places, there is ordinarily an adequate supply of water for domestic and industrial purposes, although the supply would be inadequate in case of a large fire. As an added fire protection, ponds that can be pumped into the mains in case of emergency, are maintained. Usually no effort is made to protect the sanitary quality of the water in these ponds, and if it ever becomes necessary to use the water, a serious epidemic is likely to arise. It is said that in at least one case, dead cats, dogs, and other refuse are thrown into the fire pond.

In this state, there are seven towns which do not even pretend that the public water supply is safe for drinking purposes. You will note that I have referred to these places as towns and not as cities. In my own opinion, no place in which the public water supply is not fit to drink, should be classed as a city. Petersburg, a community of about 2500 people, and county seat of Pike County, pumps raw Patoka River water into the mains. Probably few of the inhabitants drink the water, but it is always possible for strangers to drink it.

Vevay, county seat of Switzerland County, uses raw Ohio River water although a well supply is available. The people prefer the river water because it is soft. The water is not universally used for drinking purposes, although some residents use it and one doctor will argue that no harm comes from drinking the water (although he does not drink it himself).

Batesville, 2500 population, uses impounded surface water without any treatment.

Marengo, a town of 800 people, uses, without treatment, the water from surface springs in a limestone formation. In 1919, at one time, 35 individuals were being treated for an intestinal "flu" that was diagnosed in many cases as typhoid fever. Since that time other typhoid epidemics have occurred. Private wells in Marengo, being in the same limestone formation as the springs, were almost universally found to be contaminated.

Hazelton, a town of 600 people, located in Gibson County, uses untreated water from White River almost universally for drinking purposes.

All of these places to which I have already referred are located in the southern part of the state, but it must not be supposed that such conditions are confined to that portion.

Winamac, a town of 2,000 people, and county seat of Pulaski County, one of the northern counties, pumps untreated water from the

Tippecanoe River. It is not generally used by the inhabitants for drinking purposes, although it is possible for a stranger to drink the water without knowing that it is unsafe.

Rochester, a resort town of 4000 people, and county seat of Fulton County, furnishes its inhabitants with untreated water from Lake Manitou. This water is not regarded as satisfactory for drinking purposes and is not used generally for that purpose, but it is available for such use.

If the people living in these seven towns just mentoned, do not bestir themselves, and treat their public water supplies, it is only a question of time until an epidemic of typhoid will force them to act, but it will then be too late to prevent the suffering and economic loss that accompanies such an epidemic.

Other cities and towns, when faced with a water shortage or with the necessity of treating an unsafe supply, have gone ahead and made the necessary improvements, although in many cases heavy burdens have thus been placed upon the tax payers or owners.

Within the last few years, Bloomington, Valparaiso, Mishawaka, Boonville, Edinburgh and many other places have made improvements that have at least rendered their water supplies adequate for some years to come.

In closing, I wish to remind you of one "horrible example" of what can indirectly arise from an inadequate water supply.

At the resort town of Winona Lake last summer, because of an unusually large crowd attending a convention, it became necessary to flush some public toilets with water from a private untreated surface water supply, in order to conserve the public supply.

In order that water would be available for flushing the toilets, in case the private supply should fail, a cross connection with the city water supply was maintained. The details of this case are immaterial, but by some means or other this connection between the two supplies was opened, and the surface water pumped into the mains.

Between 500 and 1000 cases of typhoid fever, scattered over almost all of the States east of the Mississippi River resulted.

What happened to Winona Lake can happen, in a smaller way perhaps, to any city or town in Indiana, that does not provide an adequate, safe water supply. In all cases, before an acute shortage develops, the situation should be thoroughly studied and the necessary steps taken to provide an adequate safe water supply.

DISCUSSION

Howard A. Dill:[3] Mr. Finch's very interesting and important paper on water shortage in Indiana is a timely one, after the experience of many water companies in 1925.

This subject can be discussed in two phases. One, a water shortage due to controllable factors, such as indifference and lack of foresight, difficulty in financing needed additional water developments, pumping facilities, filtration units, distribution feeders, etc. The other phase is that of water shortage due to uncontrollable factors, such as unusual deficiencies in rainfall, as in 1925.

The first difficulty can be solved by a careful consideration of facts based on growth of the town or city supplied, increase of consumption, reduction of waste through inspection or metering, thereby determining the probable requirements for a number of years ahead. The financing of improvements can be met by new issues of stocks or bonds, if the revenues justify. If rates are too low to give proper income, hearings before the public service commission will usually result in a proper rate schedule being authorized.

A presentation of the facts to the newspapers, city officials, and business organizations will generally secure their endorsement and coöperation of such procedures, for the people are vitally interested in a pure and adequate supply of water. Too frequently such improvements are deferred for political reasons and public opinion is a valuable incentive for prompt action.

The uncontrollable phase due to an unusual lack of rainfall reducing the sources of supply is a more difficult problem. Yet these situations may be forecasted or anticipated to some extent. All sources of supplies are more or less affected by a variation in rainfall, whether they be rivers, lakes, springs, wells, or galleries. The amount and rapidity of run-off on water sheds has a greater influence on springs, wells and galleries than on rivers and lakes, and should be taken into consideration. Moderate rainfalls evenly distributed through the year will replenish underground sources to a larger degree than will excessive precipitation in a short period of time.

The Water Company at Richmond has been a Government Weather Bureau station for over thirty years, taking daily readings of rainfall, snowfall and maximum and minimum temperatures.

The record for the first eight months of 1925 gave a precipitation

[3] Superintendent, Water Works, Richmond, Ind.

of 18.18 inches. A thirty year average for the same period was 27.64, giving a shortage of 9.46 inches. This seriously affected the sources of supply, which are infiltration galleries, springs and wells. All supplies take water from gravel strata located from fifteen to twenty feet below the surface.

Due to the geological conditions (Richmond being on an anticline, and underlaid with limestone), it is not possible to secure water below

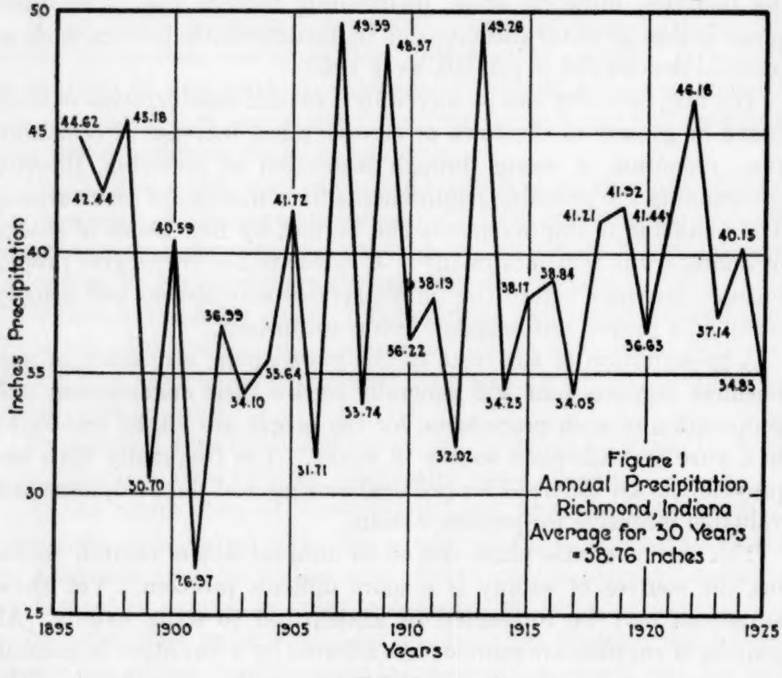

FIG. 1

the rock. The shortage of rainfall reduced the capacity of the supplies about 25 per cent. Four new wells having a daily capacity of 1,300,000 gallons were not sufficient to meet the demands and it was necessary to pump from a stream for a period of a week or ten days and to eliminate all sprinkling. This was the first time in forty years that such restriction was necessary.

By careful chlorination under the supervision and daily tests of the State Board of Health, the water was made safe for drinking, and no sickness resulted. The city health officer advised boiling, and

many consumers obtained drinking water from nearby springs, although all tests of the city water were satisfactory. The rainfall for 1925 was 34.83 inches or 3.93 inches below the thirty year average.

Figure 1 gives the annual precipitation from 1895 to 1925, the average being 38.76 inches.

In financial and business circles, charts are used to indicate the trend of prices and to forecast the general business conditions, and prices of stocks, bonds, commodities, etc. Does the rainfall chart here shown give a means of predicting or assuming that the precipitation for 1926 will be above or below the average?

We believe it does. With the exception of upward trends in 1905, 1911, 1916 and 1919, all lines show a successive upward or downward movement. There are no two successive downward movements. Therefore, the chart indicates that in 1925 the probabilty was for a downward movement, or a shortage, or, at last, only a slight upward movement. For 1926, following the tendency shown on the chart, it can be assumed that the movement will be upward, especially as 1925 closed with a deficit of nearly four inches below the thirty years average.

Sources of supplies will be replenished and there will be less probability of a shortage of water. However, as this is an uncontrollable factor, no water plant should jeopardize life and property by a failure to provide an adequate supply, and filtration and pumping facilities.

SUPER-CHLORINATION OF CHLOROPHENOL TASTES

By Louis B. Harrison[1]

The question of chlorophenol tastes in city water supplies has become a serious one. Cities in many states throughout the Union have been suffering from these tastes. Through many experiments it has been definitely demonstrated that these tastes are caused by a combination of chlorine and phenolic wastes. The remedy suggested for getting rid of them was to keep them out, and I still believe that it is the best remedy, if possible. However, in spite of all precautions taken by industries to keep these wastes out of the streams, they make their way into them, owing to the proportionately small quantity necessary to produce the taste. During the months of November and December 1925, we got doses of chlorophenol tastes in the Bay City filtered water supply, and during my investigation of the causes of these tastes I have found that an excess of chlorine destroys them.

I started experiments to find out the possibility of using super-chlorination as a means of destroying these tastes. I decided to try it out on pure phenol and also on wastes from gas works and wood distillation plants. All my experiments have been conducted at room temperature and filtered water was used in making dilutions. All tests have been made according to the standard methods of the A. P. H. A. The question of tastes was a delicate one, for what would seem very faint to one, would appear strong to others and vice versa. I have, therefore, reported, as taste, an average taste as detected by my assistant and myself. All experiments have been checked many times, and only after several months of experimentation have I put down the final results. I have selected the maximum concentrations, 1:10,000, in an arbitrary manner, assuming that this may represent the maximum concentration of waste we may possibly get at our plant.

[1] Chief Chemist, Filtration Plant, Bay City, Mich.

EFFECT OF SUPER-CHLORINATION ON CHLOROPHENOL TASTES

In order to determine the effect of super-chlorination on dilute phenol solutions, I have prepared various dilutions of phenol, starting with 0.01 p.p.m. and gradually increasing the concentration to a maximum of 0.075 p.p.m. To these dilutions of phenol I have added varying amounts of chlorine, and after standing for thirty minutes I tried them for tastes. Table 1 shows the results of the maximum concentration of phenol used when treated with varying amounts of chlorine. Chlorophenol tastes made their appearance with 0.125 p.p.m. of chlorine and then disappeared at 0.5 p.p.m. and again reappeared on increasing the amount of chlorine to 0.8 p.p.m. and

TABLE 1

Effect of super-chlorination on a dilute phenol solution

Number of bottle	1	2	3	4	5	6	7	8	9	10
Cl added, p.p.m.	0.05	0.50	0.075	0.10	0.125	0.150	0.175	0.200	0.225	0.250
Taste after ½ hour	0	0	0	0	VF	F	F	D	S	VS
Number of bottle	11	12	13	14	15	16	17	18	19	20
Cl added, p.p.m.	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
Taste after ½ hour	VS	F	VF	VF	0	0	0	0	0	0
Number of bottle	21	22	23	24	25	26	27	28	29	30
Cl added, p.p.m.	0.80	0.85	0.90	0.95	1.0	1.25	1.50	1.75	1.90	2.00
Taste after ½ hour	VF	VF	S	F	0	0	0	0	0	0

disappeared entirely at 1 p.p.m. Any further increase of chlorine up to 2 p.p.m. had no effect. No tastes appeared in all negative samples after standing for twenty-four hours.

SUPER-CHLORINATION OF GAS WORKS AND WOOD DISTILLATION WASTES

Satisfied with the results on dilutions of pure phenol I extended my research on wastes from gas works and wood distillation plants, and performed a series of similar experiments on these wastes, using phenol in dilution of 0.075 p.p.m. as a check. The gas wastes were obtained from the Consumers Power Company at Zilwaukee, Mich., and the wood distillation wastes from the Du Pont E. I. de Nemours & Company, Bay City. Table 2 shows the results of these experiments

with maximum concentration of the wastes used (1:10,000). With 0.6 p.p.m. of chlorine all samples, except wastes from wood distillation 2–3, produced chlorophenol tastes. With 0.8 p.p.m. phenol dilution and gas wastes produced tastes and with 1.2 p.p.m. of chlorine no tastes developed in any. Since experiments have shown that chlorophenol tastes increase in intensity on standing I let the bottles stand for twenty hours and then tasted them again. No taste developed in any of the bottles that were treated with 1.2 p.p.m. of chlorine.

TABLE 2

Effect of super-chlorination on wastes from gas works and wood distillation plants

	PHENOL (0.075 P.P.M.)			GAS WASTE (1:10,000)			WOOD DISTILLATION (1:10,000)		
Number of bottle	1	2	3	1	2	3	1	2	3
Cl added, p.p.m	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Taste after 30 minutes	VF	VF	VF	S	S	S	F	0	0
Res. Cl, p.p.m	0.6			0.4			0.4		
Cl added p.p.m	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Taste after 30 minutes	0	VF	0	F	F	F	0	0	0
Res. Cl, p.p.m	0.8		0.6				0.6		
Cl added, p.p.m	1	1	1	1	1	1	1	1	1
Taste after 30 minutes	0	VF	0	D	D	0	0	0	0
Res. Cl, p.p.m	0.8			0.6			0.6		
Cl added, p.p.m	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Taste after 30 minutes	0	0	0	0	0	0	0	0	0
Res. Cl, p.p.m				1.0	1.0	1.0			
Taste after 20 hours	0	0	0	0	0	0	0	0	0

REMOVAL OF EXCESS OF CHLORINE

From the results obtained it became evident that in order to destroy the chlorophenol tastes a considerable dose of chlorine is required. This dose will vary with the concentration of phenols in the wastes, as seen from table 2. Where 0.8 p.p.m. was sufficient to destroy the taste in wood distillation, it required 1.2 p.p.m. to bring about the same results in gas wastes, using the same concentration. In all cases a considerable amount of residual chlorine is left and to remove this excess of residual chlorine I have resorted to sodium sulfite. The reaction between sodium sulfite and free chlorine in an alkaline solution is

$$Na_2SO_3+H_2O+Cl_2 \leftrightarrows Na_2SO_4+2HCl$$

The sulfite is oxidized to the sulfate and the (HCl) hydrochloric acid reacts with the bicarbonates of calcium (Ca) and magnesium (Mg) liberating CO_2. From the above reaction the amount of sodium sulfite necessary to remove the excess of residual chlorine can be calculated. Instead of sodium sulfite, (SO_2) sulfur dioxide may be used, but in all experiments conducted by me Na_2SO_3 was used.

TIME REQUIRED FOR REACTION

It was then necessary to determine the minimum time required for the reaction between the chlorine and the phenolic wastes before

TABLE 3

Reaction time between chlorine and phenol

	PHENOL (0.075 P.P.M.)				GAS WASTE (1:10,000)						WOOD DISTILLATION WASTE (1:10,000)					
Number of sample	1a	3a	1b	3b	1a	2a	3a	1b	2b	3b	1a	2a	3a	1b	2b	3b
Chlorine added, p.p.m.	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Na_2SO_3 added after 30 minutes cc.		1		2			1			2			1			2
Taste after 1 hour	0	F	0	F	0	0	F	0	0	0	0	0	F	0	0	F
Na_2SO_3 after 1 hour						1			2			1			2	
Taste after 1½ hours					0	0	F	0	0	0	0	0	F	0	0	F
Na_2SO_3 after 2 hours	1				1						1					
Taste after 2½ hours	0	F	0	F	0	F	F	0	VF	0	0	0	0	0	0	F
Taste after 24 hours	0	F	0	F	0	S	S	0	F	F	0	0	0	0	0	0

the Na_2SO_3 could be added. Table 3 shows the results of the experiments conducted. After adding 1.2 p.p.m. of chlorine to dilutions of phenol, gas waste and wood distillation waste, mixing and letting stand for 30 minutes, sodium sulfite was added to 3A samples and twice the amount to 3B and then tasted after one hour. All 3A's and 3B's except 3B from gas wastes developed chlorophenol tastes and all others to which no Na_2SO_3 was added did not. Sodium sulfite was then added to all 2A's and 2B's, excepting phenols, and tasted after one and one half hours. None produced the taste.

Na_2SO_3 was then added to all 1A's after 2 hours leaving the B's for blanks. None of the 1A's developed any taste after two and one-half hours. After twenty-four hours the tasting was repeated. All blanks were negative for taste. All samples to which Na_2SO_3 was added after thirty and sixty minutes produced tastes after twenty-four hours, whereas, in those to which the Na_2SO_3 was added after two hours no taste developed after twenty-four hours. It therefore appears that the minimum time required for the reaction between chlorine and phenolic wastes is at least two hours and the sodium sulfite to produce proper results should not be added any sooner.

THE pH EFFECT

The effect of the pH value on the formation of the chlorophenol tastes is a subject that must be studied. Inasmuch as these tastes occur in Bay City's water supply during the sugar campaigns, and the alkalinity of the water is highly increased, it is quite possible that this increase in alkalinity facilitates the reaction between chlorine and phenolic substances.

TEMPERATURE EFFECT

Experiments conducted by me recently at 38°F. indicate that at a low temperature a larger dose of chlorine is required and a longer period of reaction.

CONCLUSIONS

From recent inspections and investigations, I think that the problem of keeping out phenolic wastes from the streams is a complex one, owing to the fact that relatively small quantities are sufficient to pollute a large volume of water. No disposal system for these wastes can be made 100 per cent efficient.

Super-chlorination may aid a great deal in removing these tastes and as far as laboratory research is concerned, it gives very encouraging results. It is, however, questionable in my mind whether it will work out on a large scale in practice where temperature complications may present themselves.

To me it seems that a part of our research should be bent upon finding some substitute for chlorine, irrespective of cost, if only not prohibitive and to apply this germicide during periods when super-chlorination fails and chlorophenol tastes occur.

PREVENTION OF PHENOL TASTE WITH AMMONIA

By J. W. McAmis[1]

The water supply for Greeneville, Tenn., was established about the year 1889, the water being pumped from a bold limestone spring, which issues from under a limestone ledge, near the center of the city. This spring is still used as the source of water. It seems evident from the quantity of water afforded that only a small portion can have fallen on the immediate catchment basin, and that the major portion must flow underground for a considerable distance. However, all the water must flow under a rather thickly populated area to reach the location of the spring, and is consequently subjected to contamination with about every kind of objectionable waste.

Under these conditions it is not surprising that typhoid epidemics occurred more or less frequently among the water consumers. Several of these epidemics visited the city before 1912, when chlorination was resorted to in an effort to check them. This was the beginning of the obnoxious tastes that have appeared from time to time in the tap water, causing some of the water users to demand that the chlorination be stopped. The chlorine has always been blamed entirely for these tastes and odors. This assumption is at least partly correct. The writer is reliably informed that they had never been known in the twenty-three years prior to the advent of chlorination. One employee of the water works, the pumping engineer, states that the trouble began about that time and that it has never been noted in the raw water. He also is positive that it has never been present in the freshly chlorinated water. This employee has been continuously in the employ of the water works since the beginning. These facts would indicate that the taste producing substance, if present in the raw or unchlorinated water, requires considerable time, after the entrance of the chlorine, before the reaction is sufficiently complete to produce the phenol like tastes and odors.

The term phenol taste is used here because, as near as it has been

[1] Superintendent, The Water Commission, Greeneville, Tenn.

possible to determine by tasting the water, this trouble is the same as that experienced in water known to be polluted with phenols. During the past summer three persons, who have used the Ohio river waters reported to be polluted with phenolic wastes for considerable periods, have been in Greeneville, and have had ample opportunity to compare the taste of the Greenville tap water with that of their home towns. These persons are all positive that they can detect no difference. There have been two occasions in the last six years when the taste was extraordinarily severe and it was possible to prove the presence of phenol. The first was caused by painting a standpipe with coal-tar paint, and the second occurred when some disinfectant was dumped where it found its way into the waters of the spring. The citizens of Greeneville, therefore, are somewhat familiar with what is known to be phenol taste. This taste can be duplicated by dosing samples of water with minute quantities of carbolic acid, though the writer thinks that cresol produces a taste more nearly characteristic.

The first chlorine apparatus used calcium hypochlorite for making the sterilizing solutions, and as there was no technical supervision, the regulation of the dosage was necessarily poor. In fact it was so poor that two typhoid epidemics occurred after the apparatus was installed, showing that sterilization was not always accomplished. Poor regulation has been thought to be the cause of these tastes and odors, by others who have investigated along this line. This, however, as will be shown later, cannot possibly have been the case in Greeneville.

In 1917 a standpipe was erected, creating storage equal to about one day's supply of water. If, as suggested above, the time elapsed between the entrance of the chlorine into the water and the using of the water is an important factor, then the increased storage should have been instrumental in increasing the prevalence of the taste. The records are not sufficient to show whether this was true at the time or not. In 1923 another standpipe was erected, doubling the amount of water in storage. This additional storage was put into service the latter part of 1923 and during the succeeding summer and the summer of 1925 complaints were much more numerous. During 1924 facilities for softening, coagulation and filtration were also put into service. These features permitted much closer regulation of the dose of chlorine, due to the fact that an ideal point was now available for the application of the liquid chlorine (liquid chlorine had been sub-

stituted for the hypochlorite in 1920). At this point (filter effluent) the flow of the water is uniform, the mixing is excellent and the rate of flow is indicated accurately by venturi meter.

ALGAE VS. TASTE

About this time it was suggested that blue green algae, which had been growing in the spring and immediately started to grow in the new settling basin, were responsible for the tastes and odors. The consulting engineer had specified covers for both the spring and the standpipes, partly because of this growth. Copper sulphate was used on the settling basin, but applications became necessary so frequently that it was finally also covered. This stopped the algae growth but failed entirely to abate the taste nuisance.

CLOSE REGULATION VS. TASTE

A laboratory was equipped for the new filtration plant, and it now seemed that, if there was any merit in close regulation, or in maintaining any particular dose or residual in the water after sterilization had been effected, we should be able to find the way to operate without being troubled with the chloro-phenol taste. Experiments with the idea of getting just the right dose were carried on during the entire summer and fall of 1925. The dose was reduced, so as to be just sufficient for sterilization (about 0.1 p.p.m.).

It was then gradually increased to a maximum of about 1.0 p.p.m. without any apparent change in the intensity or the frequency with which the taste appeared. It may be noted here that only a relatively small portion of the total water delivered from the plant bore this taste. It seemed to appear in spots as one writer has aptly expressed it. The writer has noted it in his own home, and frequently, though not always, on drawing water from the next spigot down the street the taste would be entirely absent. Nothing that was done in 1925 seemed to have any effect on this troublesome matter. We were able to make conditions neither better nor worse, although the taste apparently cleared up of its own accord when cold weather began. No complaints occurred from December, 1925, up to about May 1, 1926.

TESTS FOR PHENOL

In the meantime reagents were assembled for making both the Fox and Gage and the Folin-Dennis tests for phenol, in order that

tests might be made daily, endeavoring to show whether the water was only occasionally polluted and thus account for the intermittent appearance of the taste in the tap water. Samples of the raw, the filtered (before chlorination), the chlorinated, and the tap water from about the city were examined in this way. Some of the tap water which very definitely had acquired the taste was also tested for phenols. A very doubtful reaction was obtained at times, although no relation could be established between the color appearance and the phenol taste in the water. About 200 samples were examined and having gained no definite or useful information, this work was abandoned.

HOUSTON'S REPORT

The writer was fortunate to obtain a copy of the nineteenth annual Report of Sir Alexander C. Houston, Director of the Bureau of Water Examination, Metropolitan Water Board, London, England. In this report the work of Adams (in England) and Harrold (in India), regarding phenol tastes in water was described. This work (Houston and Adams) established definitely the fact that it is possible for water to become so contaminated from contact with the air in industrial districts as to give the "iodoform" taste. Attempts were made to perform some of the experiments on portions of the Greeneville water, with the idea of showing such pollution of the water supply, but all gave extremely doubtful or negative results. This was to be expected as Greeneville is situated in an agricultural district, surrounded by mountains, and with no industrial plant within a radius of 30 miles, where it is possible for phenols to be produced. The possibility of industrial waste is also eliminated, for the water supply for Greeneville issues from the ground at an elevation somewhat higher than any industrial plant in the surrounding country.

TEMPERATURE VS. TASTE

Many samples were examined during the past summer (1926) in an attempt to learn what effect, if any, the increased temperature of the water in summer would have on the formation of the taste. No definite conclusions can be drawn from the data accumulated, due to the fact that the temperature of the water in the upper portions of the standpipes reached a much higher value than any ob-

served in samples taken directly from the mains. Due to our system of operation and the layout of the piping, it was never possible to tell whether the particular water under consideration had not at some previous time been stored in the standpipes and had reached the higher temperature. With both standpipes in service and consequent longer period of storage, the maximum temperature reached by the water in the upper portions of the standpipes was 29°C. The minimum temperature observed at the bottom during the warmer months was as low as 17°C. The water having reached the higher temperatures would of course not mix readily with the colder water being pumped in at the bottom and would remain probably in the standpipe until the colder weather had reduced its temperature below that of the incoming water. This fact explains to some extent the unsatisfactory conditions, with regard to the taste of the water, existing principally in the summer and fall, and also why the trouble does not appear until late in the spring. One of the standpipes was cut out of service about the first of August in an attempt to lower the temperature of the upper layers of water, and by alternately drawing the water down low and pumping it up again, the upper temperature was lowered to 23°C. This may have brought about some slight improvement in the taste conditions, although it may have been one of the unexplicable periods of improvement, which had often occurred before. Leaving out of consideration, the possibility that the Greeneville water is in some manner polluted with a taste forming substance in summer, and that this substance is absent from the water in winter; it appears to the writer that the higher temperatures reached during the former season must have some bearing on the formation of this taste. If this is true, then the temperature at which the taste producing substance is formed lies between 17° and 23°C. There is, of course, the possibility of phenolic substances being dissolved from the pipe coating. The mineral content, however, of the Greeneville water is such that a slight scale of limestone is formed inside the pipes, consequently shutting the water off from contact with the pipe coating after a few months. Tastes have been noted which have undoubtedly been due to the installation of new piping, but these have only lasted for a few weeks and have ceased long before the carbonate coating has had time to form. Until some proof to the contrary appears, however, the possibility that the pipe coatings become more soluble in warmer water must always

be considered, although this is thought to be a remote possibility by the writer.

RESIDUAL CHLORINE VS. TASTE

Nearly all the samples examined were tested for residual chlorine at the time of sampling. This was done in order to learn what relation, if any, existed between the taste and the residual chlorine as evidenced by the o-tolidin test. Tabulation showed that about half the samples which had acquired the taste showed no residual chlorine, while the remainder showed varying amounts, ranging from zero up to as high as 0.13 p.p.m. Many samples showed larger amounts, but none of those examined had acquired the taste when larger amounts were present. Several of the samples tested zero for chlorine, but had no taste. Many of the samples were kept in glass jars, at room temperature, for some time, but no material change was evident. Those which had developed the taste at the time of sampling retained it for a long time, and the taste would not develop under these conditions when it was absent from the original sample.

DOUBLE CHLORINATION

Another fact worthy of note was brought out at this time; namely, that when a sample of water which had definitely acquired the taste was treated with a very slight (second) dose of chlorine, the taste disappeared almost instantly. This seemed to be true whether the original sample had shown residual chlorine or not. The taste did not return even after the chlorine from the second dose could not be detected with o-tolidin. This of course suggested that double chlorination might be beneficial. When this was attempted on plant scale, however, it failed to show any improvement, probably due to the fact that the first dose, which was applied to the raw water as it entered the plant, had not caused any taste to develop before the second dose had to be applied. This was necessary of course before the water was delivered into the distribution system. The second dose was applied to the suction side of the high service pump.

PRE-CHLORINATION

In chlorinating the raw water, the chlorine was first applied to the water just ahead of the softening and coagulating chemicals. In fact, they all entered the water almost at the same time and the

same place. This method spoiled the sterilizing effect of the chlorine, probably due to the formation of chloride with one of the other chemicals, although it was not determined at the time just what the trouble was. The chlorine worked beautifully when applied after the water had had a few minutes contact with the other chemicals. No change could be noted in the taste of the water delivered to the consumers while chlorinating the raw water.

CURATIVE MEASURES CONSIDERED

After being convinced that none of the above described methods could be relied on to give relief, methods of stopping the taste by the additional treatment with more chemicals, began to receive consideration. Super-chlorination with de-chlorination appeared to be the favorite method of Houston. The necessary chemical (SO_2) with which to accomplish the de-chlorination was not readily available, so this method was discarded temporarily. Treatment with potassium-permanganate is also well spoken of by Houston in his reports, but this has the disadvantage of being an active poison, and is likely to color the water unless careful regulation is maintained, so it was also passed temporarily. The only alternative then was the ammonia treatment which had been used successfully by Adams on a plant scale, and had been shown by Houston, in laboratory experiments, to have considerable merit as a "taste preventer." Preliminary calculation based on the amounts thought necessary by Houston, and quotations hurriedly obtained, indicated that the ammonia might prove the less expensive. Moreover the ammonia gas condensed in steel drums was available in the city. For these reasons it was decided to try it first.

AMMONIA USED TO PREVENT TASTE

This treatment was started on August 20, 1926, and the results have been highly satisfactory from the first. It was started while the raw water was still being chlorinated and the ammonia entered the water just ahead of the softening and coagulating chemicals, in fact at the same place that had previously proved unsuccessful for feeding the chlorine. This gave excellent results and was continued in this manner for about two months without change. The use of ammonia for prevention of chloro-phenol tastes and odors seemed to the writer to be rather a novel procedure and considerable doubt was entertained at first as to its value. However, Adams

states that this (taste producing) reaction does not occur when the organic nitrogenous content of the water is high. Great improvement was reported in Milwaukee, when the industrial waste known to contain the taste producing phenols was mixed with raw domestic sewage. In the light of the experience of Adams, Houston and Harrold, and more recently in Greeneville, it seems reasonable to suppose that the organic ammonia of the raw sewage was responsible for the improvement noted. Nevertheless the writer was still doubtful that the ammonia was entirely to be credited with the improved taste of the water. Several persons accustomed to drinking the spring waters in the vicinity of the city were closely questions, as to whether they could detect any unusual taste in the tap water. The reply was always negative. Still not thoroughly satisfied, the ammonia treatment was discontinued for a few days on three separate occasions. In three or four days the taste would appear in the water with unfailing regularity. When the ammonia treatment, however, was resumed the taste disappeared as if by magic, as soon as the system had had time to become clear of the potentially tasting water.

POINT OF APPLICATION OF CHLORINE

The most logical and convenient point for the application of the chlorine in the Greeneville plant is to the filter effluent. Consequently after about two months trial of ammonia treatment, together with chlorination of the raw water, the pre-chlorination was discontinued and the application of chlorine to the filter effluent was resumed. No change in the delightful taste was noted in the tap water so this is the method in use at present.

LAGGING CAUSED BY AMMONIA

A lagging of the sterilization was noted in the laboratory experiments by Houston, but this has not been sufficient to interfere with the proper sterilization of the water, as evidenced by daily bacterial counts on agar. B. coli has been totally absent from the daily samples examined at the plant laboratory. Houston also noted that the ultimate effect of the chlorine was somewhat enhanced by the use of ammonia. Due to the fact that the filtered water here is consistently of excellent quality, no favorable basis is afforded for comparison on a plant scale. The characteristic color appearance

in the o-tolidin test is delayed two or three minutes by the ammonia, but after three months operation we have been unable to attach any significance to this fact.

FEEDING THE AMMONIA

In attempting to feed the ammonia into the water, we first tried to feed it through an ordinary W. and T. hand control chlorinator. This chlorinator had previously been successfully used to feed chlorine and probably contained some of the residue which has always been deposited by the chlorine. The attempt to use it for ammonia was a complete failure, due to the stoppage of all the gas passages with a bluish substance which turned black on exposure to the air. The writer is doubtful whether ammonia could be successfully fed through chlorine apparatus as now manufactured, due to the high solubility of ammonia and the consequent partial vacuum created where it goes into solution. The method of feed finally adopted was to prepare a solution of ammonia water in a spare solution tank, which was available, and to feed the solution through a constant head orifice box, with which the tank is equipped. The steel drum containing the ammonia liquid is placed on a scale platform, preferably elevated above the water level in the tank when it is full. The ammonia gas is allowed to run from the steel drum down into the water in the solution tank. The scale is used to determine when the desired quantity of ammonia has entered the water in the solution tank. It is desirable to run the ammonia into the solution through a one-eighth inch needle valve so that the flow may be closely regulated. The needle valve is slowly opened until a slight cracking noise is heard in the water. If the ammonia is fed too fast the water will be drawn up and over into the ammonia container. A solution tank equipped with a stirring device is used in Greeneville, but the high solubility should cause the ammonia to diffuse quickly through the water. No mixing device should, therefore, be necessary.

DOSE OF AMMONIA

Houston states that in the laboratory a dose of 0.2 p.p.m. of ammonia as nitrogen, appeared to be sufficient in all cases, and that 0.1 p.p.m. accomplished results in some cases. Experience in Greeneville has indicated that these figures are correct. Furthermore doses three or four times larger than the values given above have not been detected (by taste) in the tap water.

COST OF TREATMENT

The ammonia treatment as practiced in Greenville is very simple and inexpensive. The cost, at prices now quoted on ammonia, would be about $0.60 per million gallons of water treated. When the advantage of delivering a water always free from the phenol taste is considered, this cost would seem to be insignificant.

ESSENTIAL DAILY LOG DATA IN THE PUMPING STATION[1]

By Isaac S. Walker[2]

I believe it is the thought in dealing with this question to limit the discussion to the operations of the steam operated pumping station, and not attempt to cover the equally important questions of purification plant records and records of water sales.

The subject is a large one and is of the greatest importance to water works operators, particularly those operating the smaller plants. It is not a new subject and many articles dealing with this and related questions have appeared in the papers of this and other water works associations. In spite of these enlightening papers, however, there are many small water plants operating in this country which, it might be truthfully stated, keep no permanent records whatever of their operations, or their water sales under different rates and classifications. This situation has been improved materially, however, in the states under public service commission control, where annual reports to the commission are required.

The topic, as stated above, is a large and important one, and somewhat difficult to handle in brief topical discussion. The first word of the title, "essential," is one to think about. It is about as difficult to differentiate between essential and non-essential as it is to classify luxury and necessity. What is one man's luxury is another man's necessity. Similarly, what might be a non-essential in one water plant would be deemed an essential in another plant. But it is the history of civilization, that luxuries, by continued use become necessities, and water works records and statistics, which might at first be considered non-essential, by their continued use and demonstrated effectiveness, soon come to be considered absolutely essential. Properly kept records and data also tend to improve the plant morale and increase the attention and interest of the attendants. There is another important point in this connection. When operat-

[1] Topical discussion presented before the Buffalo Convention, June 7, 1926.

[2] General Manager, New Chester Water Company, Philadelphia, Pa.

ing records are maintained, there is always a tendency to improve the system. This leads invariably, under progressive management, to the introduction of recording instruments, which are necessary for the successful operation of a boiler room and pumping plant.

Many papers on the value of such devices have been presented in this Association. In Volume 1, of the JOURNAL of March, 1914, page 103, our old friend Jack Diven, of revered memory, presented a valuable paper on the "Use and benefits of pressure recording gages." Mr. Diven, in his introduction, quoted from a paper by Charles A. Hague, presented in the Proceedings of this Association of 1891, page 77, entitled, "Value of pressure records in connection with water works." Mr. Hague, in turn, quoted Mr. Edwin Darling in his 1889 report of the Pawtucket, Rhode Island, Water Works, as follows: "No well conducted water works can afford to be without recording gages, and, when properly located, they will, in my opinion, pay for themselves within one year."

This statement was made thirty-seven years ago, and yet we find today many of the smaller water works without a single recording gage.

Throughout the country we find policies of operation and record keeping varying from very complete and more or less elaborate systems in some of the large plants to practically no records in many of the smaller plants. As an illustration of the first type, I would refer you to a paper entitled, "From coal to water,"[3] by our fellow member, George N. Schoonmaker, describing the operating methods of the Toledo Water Works. This plant is very thoroughly equipped with meters and indicating and recording devices, which are changed analyzed and computed daily by a trained employee, who, I would infer from the paper, devotes the major part of his time to his work. The illustration, on page 986 of Mr. Schoonmaker's paper, showing the chart desk containing some 16 charts as well as his log sheet on page 988, are of interest.

It is not to be expected that with the limited organization of the small or medium size plant, their records and analytical data of operations can be kept in the way Mr. Schoonmaker does it at Toledo, much as this might be desired. There is not a water plant operator in the country, however, who cannot afford, as the minimum of equipment of this character, one or more recording gages to furnish daily charts of the water pressure, steam pressure and vacuum.

[3] Journal, November, 1923, p. 979.

His daily log should show all the essential facts relating to the plant operations, and should at least include

- The names of the engineer and fireman on each watch
- Pump counter readings at fixed intervals, of each pump
- Counter readings at time of starting and stopping
- Total revolutions
- Total hours pumps are operated
- Total pumpage
- Pounds of coal used
- Kind of coal used
- Average B.t.u. per pound of coal
- Hours of service for each boiler
- Total ashes
- Per cent ash
- Average steam pressure
- Average water pressure
- Average vacuum
- Suction and discharge heads in feet
- Total head in feet
- Average temperature of the weather, the boiler room, the feed water and the water delivered

If means permit, it will also be desirable for the plant operator to equip his station with some or all of the various devices for the detection of waste, and improvement of efficiency, among which might be mentioned:

- A meter or meters showing the total plant output, or preferably the output from each pump
- A boiler feed water meter
- Draft gages for each boiler
- A carbon dioxide recorder
- Steam flow meters, or a measuring device for the condensate from each pump condenser
- A recording tachometer to provide a record of the pump speed
- Recording thermometers to provide a continuous record of the temperatures of the weather, the boiler room, the boiler feed water and the flue gases

The daily record charts from such recording instruments constitute the best kind of log data, and they should be carefully preserved in order and filed for permanent record. These instruments will, in most cases, be gladly welcomed by the attendants and they will relieve them from devoting their time at regular intervals, to the reading and recording of various indicator gages.

In preparing a schedule of log records for the pumping station, however, it must be borne in mind that in the average station, with possibly only one engineer and one fireman on a shift, these men have other duties than record keeping, so the system should be simplified as much as possible and should not be unduly burdensome. I am not in favor of systems such as I have seen in some stations, which require the inspection and tabulation of the readings of a multitude of indicating gages and other items every half hour or so out of the twenty-four. It is a foregone conclusion that this kind of attention will not be regularly given by the average engineer and fireman, particularly at night, and the readings and notations will be doctored and untrustworthy. This feature of possibly unreliable records of indicated readings, due to errors of reading, recording or doctoring, is eliminated by the use of recording gages.

In the average plant the cost of pumping constitutes the largest single item of operating costs. Is it not, therefore, the logical thing to keep apace with the times, eliminate guess methods, and equip our plants with modern instruments, by means of which the overall efficiency can be materially improved. The closing sentence of Mr. Schoonmaker's paper above referred to, is "Get your furnace a cash register." This is excellent advice.

I am strongly of the opinion that this topic is one which should be handled by a committee of the Association. I presume the subject properly comes under the work of the Committee on Pumping Station Betterments, and may possibly be considered by them. We also have the Committee on Essential Data for Water Records and Reports, which has given us an excellent form for such statistics for our annual reports. Log data reports of the pumping station are just as important, probably far more so to the little fellow. I am not familiar with the proposed future work of either of these committees but if this phrase of the subject has not been contemplated, it would seem to be desirable to give it their consideration.

Coöperation of existing committees is essential, as there has already been a duplication of effort, to some extent, in the work of overlapping committees. A solution for this case might be the appointment of a sub-committee of members of the two above committees, working with this Plant Management and Operation Division. Such a committee could render valuable service, particularly to the small works operator, in recommending a model form for keeping his log data, and forms for the weekly or monthly analysis of such data.

This suggestion is by no means new, and in this connection I would refer you to Earle L. Waterman's paper presented before the Iowa Section Meeting several years ago, entitled, "Operation records for small water works,"[4] in which he discusses the need of the small works operators for help of this character and expresses the view that such assistance would be greatly appreciated, and that a committee on operating records for small water works would find a large field in which to work. I am sure this suggestion is worthy of consideration.

In addition to the papers on this or related subjects, to which I have referred above, I would also direct your attention to the following:

Pumping Station Practice. Manual of Water Works Practice, 1925, p. 346.

Maxwell, D. H.: The water works coal pile. Jour. Amer. Water Works Assoc., November, 1923, p. 1072.

Cunningham, F. G.: Selection of auxiliaries for steam operated stations. Jour. Amer. Water Works Assoc., March, 1924, p. 341.

Gwinn, Dow R.: Instructions to employees at pumping stations and filter plants. Jour. New England Water Works Assoc., December, 1920, p. 284.

Behney, C. C.: The luxuries of yesterday are the necessities of today. Jour. New England Water Works Assoc., September, 1924, p. 294.

[4] Journal, July, 1924, p. 819.

COST OF OPERATING MOTOR DRIVEN CENTRIFUGAL PUMPS AT McKEESPORT, PENNSYLVANIA[1]

By Leo Hudson[2] and A. J. Richards[3]

During the year 1924 the City of McKeesport let contracts for the extension of the filter plant and the electrification of the two high service pumping stations. The work was completed and tested in time to get accurate operating conditions beginning January 1, 1925 and the plant has been in continuous operation since that date. The city is divided into two water zones, the lower part being supplied by a reservoir and the upper part being supplied by a standpipe. The two old steam plants are closed except for emergency purposes and the two new pumping installations were installed in one pump room directly connected to the filter plant extension, each set of pumps discharging through separate pipe lines, one delivering the water to the low service reservoir and the other to the high service standpipe. The entire water softening, filtration and high service pump plants are combined under one roof. The city gets its main raw water supply from the Monongahela River through a pump plant located about two miles distant from the filtration and main high service pumping plants and with this exception the entire plant is now concentrated at one point. The cost figures given in this paper apply only to the high service pumping operation and is exclusive of the low lift raw water pumping operation.

The reservoir supplying the lower portion of the city with treated water is at an average operating head of 334 feet above the bottom of the clear well. The high service zone is at an average operating head of 555 feet above the bottom of the clear well. The average heads as herein stated are the weighted average dynamic heads taken from the charts at the pumping plant. Venturi water meters were inserted on each discharge line and accurate records have been kept of the pumpage, power factor, kilowatt hours consumed and the

[1] Presented before the Central States Section meeting, September 22, 1926.
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demand. It is from these data that we have figured the total cost to own and operate the new pump plant, finally reduced to the cost per thousand gallons of water pumped against the respective heads.

During the first few months of 1925 the reservoir and the standpipe pumps were run in relay in order to keep the demand from being built up in terms of both pumps being operated at the same time. This method of operation, however, proved to be unsatisfactory to the residents in the high service zone in view of the fact that the fluctuations of head in the standpipe at the times of maximum hourly demand were such as to create a condition of slightly unsatisfactory service. To meet this demand it was finally decided on June 6, 1925 to run the pumps in parallel. This change in operation built up the demand, but of course required the same number of kilowatt hours of current consumed. At first the valves on the discharge lines were by-pass valves, but in terms of the type of motors installed it was found advantageous to change these valves for hydraulically operated valves for reasons which will be given later. This change will also warrant the reduction of the force in the pump room by two men per day after the change will have been completed.

In order to give some idea of the variation in the demand the following figures are given:

Percentage of each month of the total annual pumpage, 1925

January	9.1
February	10.0
March	7.0
April	8.0
May	8.3
June	9.2
July	8.0
August	10.8
September	6.6
October	7.4
November	7.4
December	8.2

During the year 1925, 2,046,457,000 gallons were pumped to the reservoir and 295,669,000 gallons to the standpipe. This gives a total pumpage of 2,342,126,000 gallons.

The monthly variation in the kilowatt demand and the kilowatt hour consumption was due to the foregoing monthly variation in the

demand for water and the fact that a part of the time the pumps ran in relay and a part of the time the pumps ran in parallel.

Before the plant was designed, careful consideration was given to the type of equipment to install therein. Power was purchased from the Duquesne Light Company, after careful consideration had been given to the continuity of the source of supply. The circuit of the Duquesne Light Company, was such as to supply power from two main generator stations, one the Colfax Station and the other the Brunots Island Station. Tie-in circuits were also provided with the West Penn Power Company, system for current generated at the Springdale, Pa. plant and the new Cheat River development. This main circuit system is also tied in with the Pennsylvania & Ohio Power Company, which has stations at three different points. This constitutes a tie-in with the super-power circuit of Western Pennsylvania which can draw on main stations at Cleveland, Buffalo and Philadelphia. The sub-station for this plant is a loop station providing duplicate service from two different sub-stations in the Pittsburgh District. From the time the plant was started until the present date there has been only one interruption of service and that was due to a short circuit at the Colfax Plant which lasted for about forty minutes and until one of the other plants could be thrown into service. The current furnished by the Duquesne Light Company, is in terms of their rate "F" wholesale Light and Power. Under this contract the average cost of power has been ten and seven-tenth mills per kilowatt hour and ranging from sixty mills for the first 200 kilowatt hours down to as low as seven mills per kilowatt hour and in terms of the demand charge of $1.50 per month per kilowatt for the first 100 kilowatts of demand and $1.00 per month per kilowatt for each kilowatt in excess of 100 kilowatts. These bills then are subject to a prompt payment discount of five mills per kilowatt hour for all energy billed at 60 mills per kilowatt hour, two mills per kilowatt hour for all energy billed at 27 mills per kilowatt hour, one mill per kilowatt hour for all energy billed at 13½ mills per kilowatt hour and then there is a variable discount for power factor better than 75 per cent. At 100 per cent power factor this discount amounts to 8.819 per cent.

Before the type of equipment was decided upon serious consideration was given to induction motors of both the squirrel cage and the slip ring type with the power factor corrected by the installation of static condensers or synchronous condensers; and synchronous

motors. Choice was finally made in terms of the synchronous motors because the first cost was found to be lower and for units of this size the operating cost was estimated to be less. The pumps for the reservoir are two stage series pumps while the pumps for the standpipe are four stage single suction multi-stage type of pumps. There are duplicate pumps for each installation and in order to get the installations in duplicate in so far as possible 500 h. p. motors were installed for each pump for each service. Some difficulty was experienced in the first months of the operation due to not being able to get the power factor meter properly registering and due to the fact that the valves on the discharge lines were by-pass gate valves and it was found advisable to replace them with hydraulically operated gate valves so that the motors could build up to synchronous speed before the valves were opened and the full load thrown on them with minimum amount of labor. This necessitated the closing and opening of each discharge gate valve in starting up each pumping unit and was satisfactorily done by man power, but by the installation of hydraulically operated valves the operating force will be reduced by two men per day, the third shift man being retained in the plant for general utility purposes. In other words, the labor required in closing and opening all the by-pass gate valves on the discharge lines each time the pump was started will be eliminated upon the completion of the hydraulic gate valve installation. At this time there is one hydraulic gate valve yet to be installed. In the cost tabulation herein included, therefore, the cost of operation includes these two additional men where when the hydraulic valve transition takes place entirely this force will be reduced and the cost of operating the plant correspondingly reduced. This change from the by-pass gate valve to the hydraulic gate valve is made therefore purely for the purpose of saving in the operating expenses the labor of two men per day. Finally therefore the cost of these two additional men per day is included in our cost figures, but not the cost of the additional hydraulic gate valve installation.

FIXED CHARGES ON THE COST OF THE PLANT

The contract for the four pumps and motors completely installed and tested was $27,500. The contract for the electrical work including switch-board, wiring and all other electrical equipment exclusive of the motors and exciters was $9000. Piping in pump

plant and within two feet outside of pump plant \$9500. The contract for the structural work below the operating floor that is, for the clear well under the pump plant, the pump pit, and the superstructure was \$28,560.

The cost of the pump plant itself was as follows:

Pumps and motors	\$27,500
Electrical work	9,000
Piping in the pump plant	9,500
Sub-structure and superstructure	28,560
Total	\$74,560

The City of McKeesport sold the bonds for the pump plant improvements, the filter plant extension, pipe line extension and other works incidental to the general improvements at 4¼ per cent with a slight premium. This makes a fixed interest charge on the investment of \$3169 per year or one and four-tenth mills per thousand gallons of water pumped. In terms of pumping 2,342,126,000 gallons the depreciation cost is (\$0.0005) one half of one mill per thousand gallons of water pumped.

MAN POWER COST

The operating force of the combined new pump plant consists of one half the salary of the chief pumping engineer, the salary of three pumping engineers one for each eight hour shift and at the present time the salaries of three helpers. The chief pumping engineer receives a salary of \$2260 per year, \$1130 of which is charged against the main pump plant. There are three pumping engineers at \$175 per month each or \$525 per month or \$6300 per year. There are three helpers at \$150 or \$450 per month or \$5400 per year. The total man power cost therefore is \$12,830 per year. The total pumpage as herein before given was 2,342,126,000 gallons. This therefore amounts to \$0.00548 or practically five and one half mills per thousand gallons for man power.

The net cost of electricity for the entire year 1925 as shown in table 2 was \$38,654 and for that amount 2,342,126,000 gallons of water were pumped to the reservoir and the standpipe. This makes an average power cost per thousand gallons of water pumped of \$0.0165.

TABLE 1

Depreciation determination in terms of interest compounded annually at 4 per cent

	COST (NEW)	LIFE	AGE	FACTOR ANNUAL	FACTOR ACCRUED	ANNUAL CONTRIBUTION TO DEPRECIATION	ACCRUED DEPRECIATION	COST (NEW) LESS ACCRUED DEPRECIATION
Pumps and motors	$27,500	25	2	0.0240	2.040	$660	$1,346	$26,154
Electrical work	9,000	25	2	0.0240	2.040	216	441	8,559
Piping in pump plant	9,500	25	2	0.0240	2.040	228	465	9,035
Sub-structure and super-structure	28,560	50	2	0.0066	2.040	188	384	28,176
Total	$74,560					$1,292	$2,636	$71,924

TABLE 2

Summary of electrical data

DATE	KILOWATT DEMAND	KILOWATT HOURS	POWER FACTOR	LOAD FACTOR	NET BILL
				per cent	
January 2 to March 5, 1925	444	915,000	98.3	95	8,041.70
March 5 to April 5, 1925	444	259,500	98.6	81	2,690.80
April 4 to May 6, 1925	444	268,000	99.6	84	2,722.89
May 6 to June 6, 1925	444	261,000	100.0	82	2,661.29
June 6 to July 8, 1925	740	301,000	98.75	57	3,356.82
July 8 to August 5, 1925	750	277,000	100.0	51	3,510.60
August 5 to September 11, 1925	762	375,000	100.0	68	3,841.21
September 11 to October 5, 1925	770	212,000	100.0	38	2,807.00
October 5 to November 4, 1925	480	289,000	100.0	84	2,885.02
November 4 to December 5, 1925	620	282,000	100.0	63	3,041.27
December 5 1925 to January 6, 1926	570	303,053	100.0	74	3,095.22
January 6 to February 3, 1926	610	304,000	100.0	69	3,164.44
February 3 to March 4, 1926	610	297,710	100.0	68	3,428.57
March 4 to April 5, 1926	570	292,000	100.0	67	3,059.17
April 5 to May 5, 1926	600	253,000	100.0	59	2,828.69
May 5 to June 9, 1926	600	204,733	99.9	48	2,492.45

COST OF HEATING, TELEPHONE SERVICE AND ELECTRIC LIGHT SERVICE

The total cost of the coal bill for heating the entire plant for 1925 was $2,938.36. The cubical contents of the pump room is one sixth that of the whole plant and therefore we allocate $490 as the cost of heating the plant.

The telephone service amounts to $92.40, but charging one third of this to the pump plant makes approximately $31 and the electric light cost for lighting the pump plant was $115. This makes the

TABLE 3

Summary of energy cost

DATE	CURRENT COST PER MILLION FOOT POUNDS	COST OF CURRENT PER 1000 GALLONS	
		Reservoir	Standpipe
January 2 to March 5, 1925	0.0067	0.0188	0.0310
March 5 to April 5, 1925	0.0049	0.0135	0.0227
April 4 to May 6, 1925	0.0046	0.0128	0.0214
May 6 to June 6, 1925	0.0048	0.0134	0.0221
June 6 to July 8, 1925	0.0053	0.0148	0.0245
July 8 to August 5, 1925	0.0061	0.0171	0.0283
August 5 to September 11, 1925	0.0049	0.0137	0.0227
September 11 to October 5, 1925	0.0059	0.0165	0.0261
October 5 to November 4, 1925	0.0053	0.0148	0.0245
November 4 to December 5, 1925	0.0054	0.0151	0.0249
December 5 1925 to January 5, 1926	0.0051	0.0142–	0.0236
January 6 to February 3, 1926	0.0052	0.0145	0.0242
January 3 to March 4, 1926	0.0057	0.0159	0.0264
March 4 to April 5, 1926	0.0050	0.0140	0.0231
April 5 to May 5, 1926	0.0054	0.0151	0.0250
May 5 to June 4, 1926	0.0045	0.0121	0.0208
Average	0.0053	0.0148	0.0244

total cost for coal, telephone and lights at $636 for the year or approximately three tenths of a mill per thousand gallons for the above named features of operation. One of the utility men fired the furnace for heating the plant.

COST OF OIL, WASTE AND INCIDENTAL MISCELLANEOUS SUPPLIES

The plant being practically new the cost of repairs therein has been practically nothing and $16.95 was spent in April for waste, $35 in May for additional floor hardening substance, $7.65 in

May for boots, $39.60 in May for vacuum oil, $48.64 in June for supplies, 75 cents in June for brushes, $13.80 in June for oil, $4.92 in July for charts, $10.80 in August for paint and glass, $42.97 in September for packing, $20.58 in September for oil and brushes, an additional amount of $3.90 in September for oil, $10.82 in December for miscellaneous supplies and $20.74 in December for charts making a total of $277.12. This amount divided by 2,342,126,000 gallons amounts to practically one tenth of one mill per thousand gallons of water pumped.

TABLE 4

Summary of pumping data

DATE	GALLONS OF WATER PUMPED		MILLION FOOT POUNDS WORK DONE	
	Reservoir 334 feet head	Standpipe 555 feet head	Reservoir	Standpipe
January 2 to March 5, 1925	352,763,000	44,107,000	991,000	204,000
March 5 to April 5, 1925	156,160,000	25,170,000	436,000	116,200
April 4 to May 6, 1925	166,693,000	27,676,000	465,000	128,300
May 6 to June 6, 1925	177,328,000	12,218,000	494,000	56,600
June 6 to July 8, 1925	193,620,000	21,492,000	540,000	99,400
July 8 to August 5, 1925	166,355,000	23,455,000	464,000	108,500
August 5 to September 11, 1925	222,485,000	33,782,000	619,002	156,200
September 11 to October 5, 1925	135,800,000	21,605,000	379,000	99,883
October 5 to November 4, 1925	153,399,000	26,417,000	428,000	122,000
November 4 to December 5, 1925	152,427,000	29,982,000	425,500	138,500
December 5 1925 to January 6, 1926	169,427,000	29,765,000	472,000	137,600
January 6 to February 3, 1926	169,465,000	29,003,000	472,000	134,300
February 3 to March 4, 1926	168,050,000	29,215,000	468,000	135,000
March 4 to April 5, 1926	166,614,000	30,314,000	467,500	140,100
April 5 to May 5, 1926	140,350,000	28,721,000	392,000	133,000
May 5 to June 9, 1926	143,735,000	34,675,000	401,000	160,400

Summary of cost per thousand gallons of water pumped

Interest on investment	$0.0014
Depreciation charges	0.0005
Man power cost	0.0055
Energy cost	0.0165
Heat, telephone and electric light	0.0003
Oil, waste and incidental expenses	0.0001
Total	$0.0243

POPULATION DATA

The City of McKeesport supplies the City of McKeesport proper, East McKeesport, Versailles Township, Versailles Borough and Port Vue Borough. The total population for the districts supplied for 1925 according to the post office record in McKeesport is 63,000. During this time 2,342,126,000 gallons were pumped and this means a per capita consumption of 102 gallons per day.

The total cost to own and operate this plant for 1925 was $56,858 or $.90 per capita per year for the high lift pumping operation only.

The pumps are the DeLaval type furnished through the Dravo Doyle Company. The motors were the Westinghouse Electric Manufacturing Company motors. The electrical work was done by the Franklin Electric & Construction Company, through the Pitt Construction Company; the general contract was with the Pitt Construction Company of Pittsburgh. The gate valves, both by-pass and hydraulic, were furnished by the Rensselaer Valve Company.

ELECTRICALLY DRIVEN PUMPING STATIONS AND PEAK LOADS[1]

By J. A. Rue[2]

A peak load period in the electrical industry is known as that portion of the day when the load demand for service by the customers is at the maximum. In this paper we will vary this definition to cover that portion of the day when the demand is materially greater than the average for the twenty-four hours. This usually occurs from 8:00 a.m. until noon and from 1:00 until 4:00 p.m., and again from 7:00 to 8:00 p.m. This general curve will vary between wide limits and is influenced by the season of the year, loads, climate and many other factors.

The ideal load for any power system would be a constant uniform demand of the capacity for which the system was designed. This condition seldom if ever exists, and load curves show the demand to be quite variable.

The modern power plant is designed and equipped with sufficient generating capacity to serve amply its territory at peak load conditions. Therefore, the total station capacity is used only during the peak loads. A part of the equipment is either idle or operating at less than full load the remainder of the day. It has been said that if an electric company can double its power factor, which is the ratio of average demand to maximum, the value of its investment is practically doubled. Since the load factor bears such an important relation to its net earnings, every electric company is desirous of improving its load factor by obtaining all of the off peak business possible.

The electric light and power companies, in order to improve the load factor, can afford to offer special rates for any class of business that will use the service during the off peak hours. Such industries as bakeries, coal mines, drainage districts and some kinds of factories do avail themselves of these special rates.

[1] Presented before the Illinois Section meeting, March 24, 1926.

[2] Water Engineer, Central Illinois Public Service Company, Mattoon, Ill.

The electric traction companies have partially solved their peak load problem by developing sufficient freight hauling during the off peak hours of the night to balance the passenger traffic during the day time.

A city contemplating the design of a new pumping station or the revamping of an existing station should learn from the power company serving that community what rate could be secured by pumping during off peak hours. This rate might justify a comparatively large investment for elevated storage capacity or other special features of design. The use of electrical energy for pumping water, whether on peak load or off peak load, is not only convenient but economical, for the investment per horse power is low, the maintenance is small and the simplicity of operation is a distinct advantage. These advantages have been recognized by many water companies and municipalities throughout the state which have electrified their pumping stations during the last five years.

While it is not possible for all water stations to operate their pumping equipment during off peak hours, there are, however, a large number that could satisfactorily operate in this manner. The water stations that could not wholly use off peak service could in a great many instances do part of the pumping during the off peak hours.

A great many small towns of 2000 population or less have an elevated storage of sufficient capacity to last through the electric peak load period. Such towns could probably reduce their power bills by operating their plants at night instead of in the day-time. There are also towns so blessed by nature as to have a natural elevated storage and these can do all of their pumping on the off peak period.

There are many cities which have large surface storage sufficient to last two or three days. The reservoirs are either of concrete or earth and are replenished by pumping from deep wells, rivers, or other sources of supply. A town having this arrangement can fill the reservoir during off peak hours and do the necessary service pumping during the peak hours, and in this way effect a considerable saving in operation.

The determination of the amount of money that can be spent on elevated tanks and on surface storage of sufficient capacity to permit operation with cheap off peak power is a problem of economics. The water plant engineer can readily calculate the savings to be

secured by lower rates from pumping during the off peak hours as compared with the interest on the investment necessary to install elevated tanks or to build surface storage. It would be surprising how large an amount can be spent in this connection with no increase in the total operating cost. The Illinois Fire Inspection Bureau will give a better insurance rating to towns having a large elevated storage than to towns with small storage.

Rapid strides have been made in the perfection of electric metering equipment and it is now possible to install a dual meter set with time switch so that it will meter the power used during the peak period on one meter and the power used on the off peak period on the other meter. By this method different rates can be charged for the power used over the two different load periods.

With this arrangement the operation of the water plant could be such that the greatest saving could be effected by operating as many hours as is possible during the off peak period.

Operation with this dual metering equipment has already been used by various classes of power users. In my opinion, there is no reason why the water plants cannot take full advantage of such operation.

In conclusion, it is recommended that every manager of a water plant investigate the possibility of operating a part or all of their pumps on off peak load periods.

COST ACCOUNTING FOR PIPE LAYING JOBS[1]

By Homer V. Knouse[2]

Cost accounting as an element of utility operation or construction is of universal appeal. The size of the property or the extent of the operation does not greatly affect the interest, for in any case the balance sheet is the principal index of the success of the enterprise. The operator of a small property must conserve his resources and scrutinize his expenditures quite as carefully as the department head or executive of a plant supplying many thousands. Failure to watch carefully all expenditures and neglect in the study of costs in terms of units of output or construction will ultimately result in embarrassment or in many cases failure.

Cost accounting may have several objectives, and each will require a somewhat different treatment. If it is for the purpose only of maintaining a perpetual inventory of the plant, much less detail will be necessary than if it is for the guidance of the estimating department. The power plant operator will care less about the total tons of coal burned than in the coal cost per thousand gallons of water pumped or kilowatt hour of power delivered to the bus bars. The ideal system is one, of course, which will entail the minimum amount of labor in its development and use, and which will contain elements from which each class may obtain the information they desire. Much time and study has been given to the subject by executives and accountants, and in the larger plants the entire time of departments of considerable size is required to collect necessary data and put it in shape to be of use by each of the interested persons in the organization.

While the plan described herein contains all the elements which could be desired by any department, whether it is the accounting, the engineering or operating, it has been developed to serve, in addition to the above, a part of the organization which is not generally considered when systems are developed, namely, the gang foreman. The

[1] Presented before the Iowa Section meeting, November 4, 1926.

[2] Construction Engineer, Metropolitan Utilities District, Omaha, Nebr.

foreman should be given consideration, for the economical handling of construction work rests largely on his shoulders. By placing in his hands such data as will enable him to analyze his methods of doing work it is inevitable that greater efficiency will result. The foreman is thus raised from the status of a "herder" of common labor to that of a man who has responsible charge of a small business, and the proper type of foreman is bound to respond to this responsibility and increase his own efficiency as well as build up a better gang of men under him.

This paper will describe the plan used to obtain costs of laying water and gas pipe and variations will suggest themselves to adapt it to other classes of work or to particular local conditions. Special attention has been given to the element of time, so that as complete data as possible are available to the foreman within a day or two after the completion of the job, in order that he may have all the circumstances fresh in his mind when checking his costs.

Data for labor costs are reported by the foreman on his daily time sheet to the timekeeper. Labor is subdivided as follows:

Foreman and miscellaneous
Excavating
Pipe laying, including jointing
Refilling, including flushing or tamping
Cutting paving
Repaving

From these data the Timekeeper's Department posts totals to a labor recap sheet daily, and immediately upon the completion of the job the totals and unit costs are figured and a summary forwarded to the foreman. No attempt is made on this preliminary report to include material costs, since the compilation of material costs requires more time, and the amount of material used is largely out of the foreman's hands.

All material is delivered by the storekeeper on orders of the foreman and quantities drawn are checked against the quantities as used in the job. A field clerk makes a report of all material used, as well as of the location of the completed line, location of valves, hydrants, special castings, and structures of other utilities which are encountered during the progress of the work. Notes are made as to the size of paving cuts, character of the weather, and any other element which would affect the cost of the work. The completed report is a

complete record of the job and is used by all departments for their particular records. The Accounting Department is interested in the total cost to be added to the plant values, and notes the additional hydrants that are to be billed to the city; the Engineering Department posts the data on the necessary maps; the Tax Department uses the data for extending the assessments against abutting property. Data as to hydrant pressures, dead ends, etc. are posted on the proper records and the report finally is filed as a permanent record. A summary of the total cost is then forwarded to the foreman who had charge of the work for his information and guidance.

A marked increase in efficiency and decrease in unit costs has been noted since this method of aiding the foreman has been in effect. There is a friendly rivalry between gangs to get low costs and large footage of pipe laid, and any element out of their own control which affects costs is quickly brought to the attention of the General Foreman for adjustment. As an example of this kind, a Foreman reported that he could not keep down his costs of refilling ditch due to the large amount of trimming or cleaning up when a particular backfiller was used on the job. A study of the operation of this backfiller disclosed that it was making about 40 per cent more footage than another similar machine, but that this gain was in fact at the expense of careful cleaning up. The unit costs of this machine were of course less than the other machine, but when the cost of additional labor was added it was clearly demonstrated that the operator on the "slow" machine was the most efficient.

Carelessness in the handling of material by truck drivers which caused breakage produced an increased labor cost on the job and reports were soon available from the Foreman which located the trouble. Defective castings and poor quality of any material are more carefully checked in order that there will be no additional or unnecessary labor to complete the job.

THE WATER WORKS PLANT OF BUTTE, MONTANA[1]

By Eugene Carroll[2]

In the following paper the writer gives a short description of the water works plant of the Butte Water Company. Coming to Butte in the fall of 1891, to superintend the construction of a masonry dam on Basin Creek, the writer was soon after made superintendent, and ever since has been in charge of the design, construction and operation of this plant.

At first thought the plant impresses one as being complicated and of entirely too large a capacity for a community of 65,000 people. When it is considered, however, that the mining properties in the vicinity of Butte, large consumers of water, are dependent entirely on this plant, and when it is realized that in case of fire under ground, an enormous amount of water is required quickly, the reason for building a plant of such large capacity is explained. The apparently complicated design, requiring five separate distribution systems, is caused by the contour of the territory served, and its high elevation above sea level.

While always avoiding extravagance in the construction of the plant, economy at the expense of sound engineering principle has never been the practice. Every part is constructed of the best material obtainable and extreme care has been used in its erection. To this may be attributed the fact that no costly mistakes have developed in the physical plant, and our operation costs have always been relatively low. If the plant were to be rebuilt at the present time, the writer knows of no material changes which he would consider advisable, other than improved machinery.

HISTORICAL

During the year 1891, A. S. Biglow, President of the Boston and Montana Mining Company and Associates organized the Butte City Water Company. They purchased from the late Senator W. A. Clark

[1] Presented before the Montana Section meeting, April 17, 1926.

[2] Vice President and Manager, Butte Water Co., Butte, Montana.

and Associates, the water works plant of Butte, consisting of nineteen miles of distribution mains, having 1750 consumers, serving a population of about 11,000.

The construction of the new plant was started October 1, 1891 and in the spring of 1892 work was started on the construction of the Basin Creek Dam. Owing to the rapid growth of the community and mining enterprises in the vicinity, coupled with political trouble with the city authorities, and algae trouble with the water supply, the Company soon found itself in financial difficulties, conditions making it impossible to finance needed improvements and extensions. In 1898 the Company was placed in the hands of a receiver and reorganized, the new Company being known as the Butte Water Company, which procured $1,000,000 additional capital and proceeded with the construction of the additional supply required from the Big Hole River. Since that time matters have been moving smoothly, the Company gradually paying off its indebtedness, and living in the hope at some future time of giving some return to the original promoters and stockholders. The Butte Water Company is incorporated under the laws of New Jersey, with a capital stock of $5,000,000, three million of which has been issued. There is no bonded indebtedness.

GENERAL DESCRIPTION

The Butte water works system supplies water to what is known as the Butte Mining District, which includes the incorporated cities of Butte and Walkerville, and communities adjacent, known as Centerville, Meaderville, East Butte and South Butte. The district extends over an area of about fifteen square miles, and varies in elevation from 5400 feet to 6368 feet above sea level. The mines of the Anaconda and other mining companies are within the district.

The problem of supplying with water, a large community located at a high altitude, practically on the Continental Divide, presents a most interesting problem, more complicated from the fact that the only stream of any consequence within the vicinity, Silver Bow Creek, is unfit for human consumption because of its being used for general sewage of the mines and inhabitants. The streams above these industries are small, and notwithstanding the development of two of them, made available by large storage reservoirs, the annual gravity water supply amounts to only about 6,000,000 gallons average per day. For this reason it was necessary to develop a supply from the

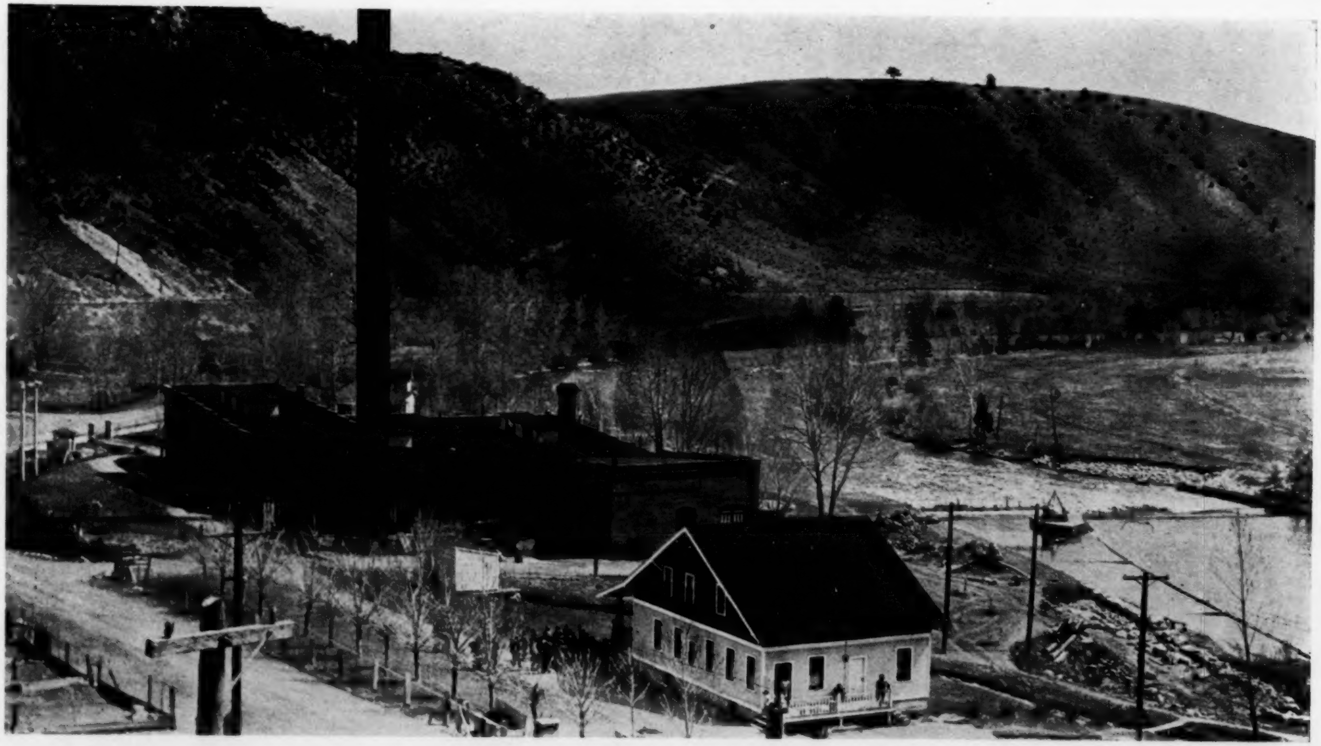

Fig. 1. Big Hole Pumping Plant, Butte Water Company

Installed 1899; electrified 1913; total pumping capacity 15 million gallons daily. Supply from Big Hole River. Elevation 5402 feet above sea level.

Big Hole River, on the opposite side of the Continental Divide, pumping the water across the Divide, a distance of about 27 miles. Butte is located on the side of the mountain within a horsehoe in the main Continental Divide, and the district is drained by Silver Bow Creek, one of the head waters of the Columbia River, which flows through a box canyon to the West.

The entire system is comprised of two pumping stations, five storage reservoirs with a total capacity of over 700,000,000 gallons, 85 miles of transmission mains, ranging in size from 12 to 26 inches in diameter, five distributing reservoirs with a total capacity of about 18,000,000 gallons with 150 miles of distributing mains ranging from 12 to 20 inches in diameter. The pumping stations are located at the Big Hole River and West Side. The storage reservoirs are located on Basin Creek, and on the head waters of Silver Bow Creek. The South Fork Reservoir located on Divide Creek is both storage and distributing.

The distributing system is divided into 5 divisions as follows: The *Moulton System* which supplies the inhabitants of Walkerville to the North and receives its water from the Moulton Reservoir; the *High Service System* which supplies the community of Centerville and the adjacent mining properties, receiving its water from the Moulton Reservoir, augmented by the West Side Pumping Station; the *Middle System* which extends from the north limits of the City of Butte to elevation 5700 feet on the south, receiving its water from the West Side Reservoir, which is supplied from the Big Hole System; the *Lower System* extending from elevation 5700 feet to the south limits of the City of Butte including the community of Meaderville and the mining properties in that vicinity, receiving its water from Basin Creek Reservoir augmented by the Big Hole System; the *South Side System* including all of the community south of the south limits of the City of Butte, receiving its water from the South Side Reservoir which is supplied from the Basin Creek Reservoir.

All systems are connected together, divided by valves, so that in case of necessity it is possible to augment any district from the system above.

RESERVOIRS

Basin Creek Dam No. 1, located on Basin Creek, 13 miles south of the city limits, was started early in the Spring of 1892. It is of monolithic construction, consisting of large blocks of granite with

FIG. 2. LAYING 26-INCH STEEL PIPE, WELDED JOINTS, THROUGH SOLID ROCK IN THE ROCKY MOUNTAINS

the interstices filled with concrete. The water face is finished with cut stone. This construction extends to elevation 5860 feet and, in 1913, 13 additional feet were added of reënforced concrete, making the elevation of the coping 5873 feet above sea level. The dam is built at the junction of Bear Creek with Basin Creek and has a length of crest of 270 feet, built with a gravity section on a curve of about 350 feet radius. The crest is 73 feet above the creek bed and 101 feet above the lowest point of the foundation. It contains about 11,000 cubic yards of masonry, and 3600 cubic yards of concrete. Eight thousand pounds of steel were used in reënforcement of the last 13 feet built of concrete. There are three 20 inch cast iron pipes through the bottom of the dam, two being used as supply lines, the other as a blowoff pipe, all regulated by valves located in a valve house at the lower toe of the dam. The water is received in the pipes through elbows just inside of the water face, on which valve seats are placed to receive screens or covers lowered and regulated by a derrick on top of the dam. The reservoir formed by this dam has a capacity of 370,000,000 gallons.

Basin Creek Dam No. 2, located about a mile and a quarter above No. 1 on Basin Creek was originally constructed in 1898 as a rock filled crib dam, and reconstructed in 1907 by placing a concrete core wall on the vertical water face of the dam with an earth fill. It is 40 feet high, and has a top width of 16 feet with a length of crest of 320 feet. The reservoir formed has a storage capacity of 60,000,000 gallons. The upstream face of earth has a slope of 1½ to 1 and is paved with hand-laid rock. There are 46,000 lineal feet of logs, 9934 cubic yards of rock, and earth filling, 8511 cubic yards of earth face, and 985 square yards of rock paving. A 12-inch pipe regulated by a valve at the lower toe of the dam, turns the water from the reservoir into the creek below, through which it flows into Basin Reservoir No. 1. In addition to storage this reservoir is used during the spring months as a settling basin.

South Fork Dam is built on the South Fork of Divide Creek, a stream heading on the Continental Divide and flowing into the Big Hole River. It is an earth dam with a concrete core wall, having a maximum height of 33 feet with a top width of 16 feet and a length of crest of 315 feet. The upstream face is on a 2 to 1 slope paved with rock, handlaid, with a down stream slope of 2 to 1. This dam was constructed in 1899 and forms a reservoir having a capacity of 13,472,000 gallons. In addition to storing the waters of Divide

Creek, it holds the water pumped from the Big Hole Station. This dam consists of 23,750 cubic yards of earth fill, 1475 cubic yards of concrete, 1967 square yards of paving, with a concrete spillway

FIG. 3. WELDING A JOINT ON 24-INCH STEEL PIPE AT BUTTE, MONTANA

containing 75 cubic yards. The water runs by gravity from the South Forest Reservoir to the Westside distributing reservoir in town.

Moulton Dam No. 1. This dam is located on the head waters of

Silver Bow Creek about 7 miles north of the city limits of Butte. It is an earth dam with a concrete core wall, having a height of 60 feet with a top width of 15 feet and a length of crest of 500 feet. It was constructed in 1907, the upstream face having a slope of 2 to 1, paved with hand-laid rip rap, with a slope of 2 to 1 on the downstream face. A 24-inch outlet pipe, of cast iron embedded in concrete, turns the water from the reservoir into the creek below, regulated by a valve located in a valve chamber just inside of the upper toe of the dam. There is also an 8-inch cast iron blowoff pipe. The top of the dam is elevation 6756 feet, 60 feet above the creek bed, the bottom of the core wall extends 28 feet below the creek bed. It forms a reservoir having a capacity of 261,000,000 gallons and has a large concrete overflow. It contains 83,866 cubic yards of embankment, 4429 cubic yards of concrete and 5658 square yards of paving.

Distributing reservoirs. There are five distributing reservoirs of various construction, all of concrete. Two small ones built square with concrete walls below the surface, and covered, for the Moulton System; one concrete triangular reservoir for the high service system; one of concrete for the middle system; one circular concrete reservoir for the Southside system.

PUMP STATIONS

The Big Hole Pump Station, located on the Big Hole River, contains two horizontal triple expansion Nordberg pumps, and one Worthington five stage turbine, all driven by electric motors. The Nordberg pumps were originally installed to be driven by steam, but in 1913 were converted to electric drive. Pump No. 1 was converted by replacing the fly wheels with herring-bone gear driven by an electric motor. Pump No. 2 was electrified by disconnecting the steam end and installing at the other end an electric motor, driving two twenty-four feet wheels with rope drive. The steam connection of No. 2 was not disturbed and in a short time can be reconnected in case of emergency. Pump No. 1 has a capacity of 5,000,000, pump No. 2, 4,000,000 and pump No. 3 which is a 12-inch, five-stage horizontal turbine pump, has a capacity of 6,000,000 gallons per day. Pumps Nos. 1 and 2 are driven by induction motors, of 800 horsepower each. Pump No. 3 is driven by an induction motor of 1300 horsepower.

A small rock filled crib dam is built in the river to form an intake reservoir, from which the water enters a concrete intake chamber

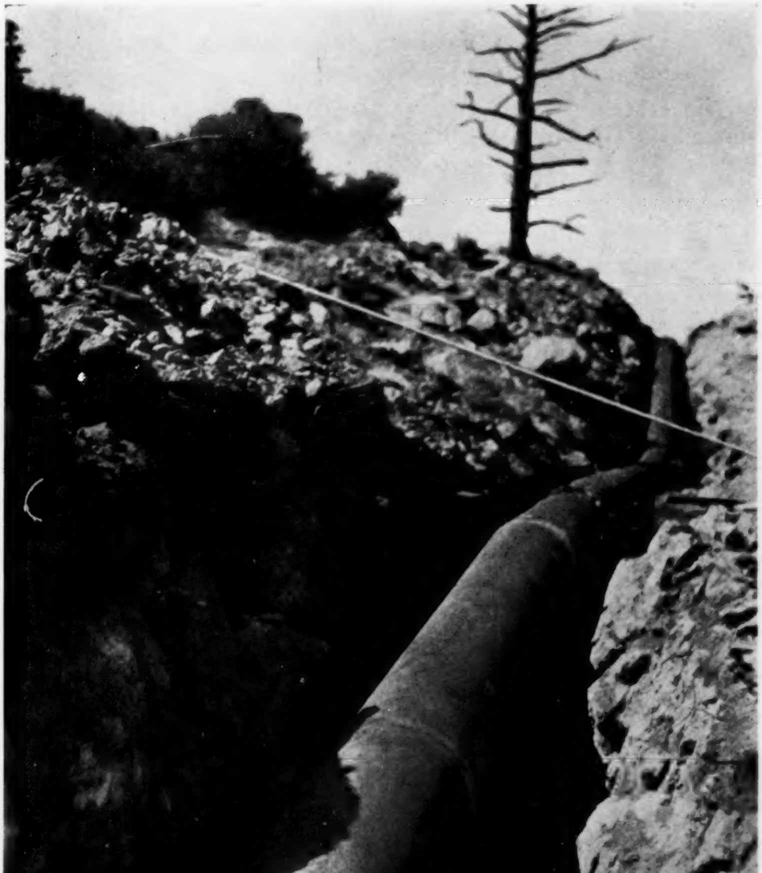

Fig. 4. A Reverse Vertical Curve Through Solid Rock; 26-inch Steel Pipe, Welded Joints

connected to a suction well near the pump station, by two concrete conduits. The suction pipes of the pumps, protected by foot valves, receive their water from the suction well, the water being screened at both the intake chamber and where it enters the suction well. A Wallace and Tiernan plant chlorinates the water in the suction well, using from 1 to 3 pounds per million gallons of water pumped, depending on the bacterial condition of the raw water.

The elevation of the engine room floor is 5402 feet above sea level and the water is pumped from this station to elevation 6152 feet, where it enters the South Fork Reservoir. The friction loss in the pipe lines between the Big Hole Station and the South Fork Reservoir requires the operation of the pumps under a pressure of from 360 to 375 pounds per square inch.

As a reserve equipment, to be used in case of emergency, two 300-horsepower Stirling water tube boilers are kept in condition for the steam end of pump No. 2. A temporary triple expansion steam pump was installed in 1899, and in 1901 pump No. 1 was installed, followed in 1907 by pump No. 2, and in 1917 by pump No. 3. Pump No. 2 was electrified in 1907 and pump No. 1 in 1913.

The pump station is of ordinary brick construction on concrete foundations, with concrete floors, and is equipped with traveling cranes, and repair shop. Three modern houses take care of the employes, the grounds being beautified and maintained as a public park.

The West Side Pumping Station, which supplies the deficiency in the high service system is located at the east end of the Westside Reservoir, and contains two Nordberg rope driven pumping engines, horizontal duplex type, driven by fourteen feet rope wheels mounted on crank shaft. Each pump is driven by a three phase 150 horsepower induction motor, 450 r.p.m., pumping against a pressure of 150 pounds. The suction pipes from the pumps connect directly to the West Side Reservoir and deliver the water through the high service system to the high service reservoir at elevation 6255 feet, the elevation of the pump house floor being 5949 feet. The capacity of the electric pumps in this station is 2,000,000 gallons in twenty-four hours for each pump.

A triple expansion duplex Worthington pump operated by two-eighty horsepower horizontal tubular boilers is kept in reserve at this station. Originally the equipment of this station was steam, installed in 1899, the new electric pumps being installed in 1907 and 1910 respectively.

The building is of brick construction on concrete foundations with concrete floors, and equipped with a travelling crane. The grounds around the westside reservoir and pumping station are beautified and maintained by the Company as a public park. A modern brick residence is located near the pump station for the watchman and a large warehouse is maintained on the grounds.

INFLUENT PIPE LINES

Connecting Basin Creek Reservoir with the city system are two influent pipe lines constructed in 1892 and 1914. They are parallel, the older one consisting of 49,750 lineal feet of 24-inch banded Redwood continuous stave pipe, the second line consisting of 38,100 lineal feet of banded continuous stave fir pipe, and 12,930 lineal feet of 24-inch Matheson joint steel pipe.

Connecting the Big Hole Pump with the Westside Reservoir are two influent pipe lines. The first was constructed in 1899 and 1900, and has a length of 27.1 miles, from the Big Hole Pumping Station to the West Side Reservoir, with a capacity of 8,000,000 gallons per day. The second line built in 1920 practically parallels the older line with the same capacity. The older line known as No. 1 consists of 3055 feet of 26-inch riveted steel pipe, 43,502 feet of 26-inch wooden pipe to the South Fork Reservoir, thence 97,912 feet of 24-inch wood and 26 inch steel pipe to the West Side distributing reservoir in Butte. Banded continuous stage redwood pipe is used for heads up to 250 feet and riveted steel for higher heads. Pipe line No. 2 has a total length of 139,958 feet and consists of 3525 feet of 26-inch and 22,211 feet of 24-inch lap welded steel pipe, and 43,422 feet of 26-inch, and 70,800 feet of 24-inch continuous stave redwood pipe. The wood pipe was used for all heads under 300 feet. On both these lines 26-inch pipe was used between the Big Hole Pumping Station and South Fork Reservoir and, 24-inch between South Fork and Westside Reservoir.

On each line between South Fork and West Side Reservoirs four regulating chambers are installed to reduce the pressure limits for low head wooden pipe, thereby making a large saving in first cost. Each chamber contains a valve operated by a float in the chamber on the outlet side. Each is provided with an overflow, which, in case the valve fails to work, will prevent a pressure on the pipe line below.

On No. 2, lap welded steel pipe, furnished by the National Tube

Company with beveled ends, was used. It varies in thickness to conform to the pressure and was delivered in varying lengths, averaging 16.83 feet. The oxyacetylene process was used to weld circumferential joints. It is interesting to note that after five years of operation it has proven entirely satisfactory. Welded joints were adopted along the lines for economy, both in construction and delivery of material, the cost being much less than any other available joint. Weir chambers are installed on each line, where it enters the Westside Reservoir.

Connecting the Moulton Reservoir with the distributing reservoirs north of Walkerville is an influent pipe line of 12-inch wood pipe and 16-inch steel pipe, 22,900 feet long. Fifty-seven hundred feet of 12-inch wood pipe connects the reservoir to a sand and screen chamber from which point it is carried through 17,200 feet of 16-inch Matheson joint steel pipe, connecting to the distributing reservoirs. The screen chamber is also connected to the creek, and at certain seasons of the year considerable water is secured in addition to the water from the Reservoir. At the lower end of this line a weir chamber is installed before entering the distributing reservoirs, and a Wallace and Tiernan installation chlorinates the water.

Connecting the waters of Fish Creek with the Basin Creek System is a 14-inch wire wound fir pipe, diverting the head waters of Fish Creek across the Continental Divide, emptying into the water shed of Basin Creek. A concrete weir chamber is installed on the summit, from which the water flows through natural channels to Basin Creek. This pipe line takes the water from Fish Creek at an elevation of 8493 feet, crossing a deep valley with a maximum pressure of three hundred feet and discharging into Basin Creek water shed, at elevation 8400 feet. It has a capacity of 3,231,000 gallons per day.

At a point about 2 miles south and west of the City limits a 12-inch pipe connects the two Big Hole lines with the Basin Creek System. This cross connection is made to enable water to be delivered from the Big Hole System to the lower Basin Creek System, and South Side System, without passing through the Distribution System.

CITY DISTRIBUTION SYSTEM

Kalamein steel pipe is used exclusively throughout the distribution system, and being flexible, meets very satisfactorily the unusual conditions imposed by the continual movement of the ground caused by mining operations. The movement of the surface causes tele-

scoping and pulling of joints, failure being indicated by small leaks, rather than sudden breakage, as would be the case with cast iron pipe. In some instances joints have been telescoped as much as 11 inches.

In parts of the system the ground is impregnated with sulphuric acid and considerable trouble has been experienced by the water company from this cause. Various experiments have been made from time to time with a view of protecting the pipe in these districts, and we have found the only satisfactory protection is embedding it in concrete through the acid soil. Considerable trouble from electrolysis was experienced until the Street railway improved the method of overhead return and welded the greater part of the rail joints. The oldest pipe now in use was laid in 1886, and a considerable amount was laid in 1891, extensions having been made every year since.

Mains are laid with a cover of 6 feet, the average frost penetration being 5 feet, with a maximum of seven feet. Recording pressure gauges are maintained at the Galena Street Shop, at an elevation of 5699 feet and on the West side and Upper Basin Creek Services. The system is so divided that a pressure of from 105 to 117 pounds is carried in the congested district with a minimum of 60 pounds in the outlying residential districts at extreme elevations.

The South Side System is located between elevations 5425 and 5510 feet, and is almost entirely residential. A twenty inch main extends east from the south side Reservoir along the southern boundary of the area served, with 12-inch mains branching to the north.

The Lower System receives its water from the Basin Creek Reservoir and supplies residential and minor mercantile districts, an important warehouse section and mining district. The elevations range from 5510 to 5710 feet. Two 20-inch supply mains from Basin Creek transmission mains extend to the southern limit of the service continuing in two parallel lines on each side, of 18- and 16-inch diameter, which are cross connected at various points by 12-inch mains.

The Middle System supplies the main business section and high class residential district. The supply is by gravity from the West Side Reservoir, elevations ranging from 5600 to 5910 feet. The district is supplied through a 16- and a 14-inch main, running from the Reservoir around each end of the district, grid ironed with 12- and 10-inch mains.

The High Service System supplies several small mercantile sections

and residential districts north of Butte, and mining properties. This system is supplied from the Westside pump, which delivers water through the system to the high service reservoir. A part of the supply for this system is by gravity from the Moulton Distributing Reservoirs. Mains range from 6- to 14-inch.

The Moulton System supplies a section at a higher altitude than the high service reservoir, principally residential. It receives its water from the Moulton distributing reservoirs through two 12 inch mains, extending through the area.

In the congested districts the mains are mostly 10- and 12-inch gridirons, but owing to the topography of the country there are a number of dead ends in the outlying districts, though not excessive. Valves are liberally distributed throughout the system and fire hydrants are maintained to furnish fire protection to the community and the mining companies, without the use of steam fire engines. No mains less than 6-inch is used to supply the fire hydrants and the standard maintained for fire protection is very high, as evidenced by reports of the National Board of Fire Underwriters. Frequent flow tests by the Underwriters indicate that the distribution system is ample in all parts of the district.

Daily record of the consumption is measured by weirs and Venturi meters on the supply conduits, readings being taken twice daily. The maximum month was January, 1917, when the daily consumption averaged 13,600,000 gallons, but the average annual daily consumption runs between 9,000,000 and 11,000,000 gallons. The records show that the heaviest consumption is during dry periods in midsummer, and during protracted periods of cold weather, when taps are left open to prevent freezing. Over 20 per cent of the entire consumption is used in the mines through metered services, though only 5.7 per cent of the total services are metered. The distribution system consists of 792,639 lineal feet of pipe, varying from 2 to 20 inches in diameter, 2-inch being used only for small residential gridirons, the minimum size of mains for fire protection being 6-inch. There are 765 fire hydrants in commission, 113 of which are paid for by private parties, the balance being under contract to the City of Butte, Silver Bow County and the City of Walkerville. On January 1, 1926 there was a total of 10,763 consumers, 861 of which were metered. It is our universal custom to meter all large consumers, private residences being unmetered, unless requested by the consumer. Meters are owned and installed by the company, without

expense to the consumer, with a minimum charge for different classes of service. House connections are made by licensed plumbers at the expense of the consumer, the Company furnishing the Corporation Cock and making the tap free. Standard curb cocks are sold at cost by the company to plumbers. The company maintains the main lines that pass the mining properties, but all extensions are paid for by the mining companies. All service pipes to private consumers must be laid in a ditch at least 6½ feet deep, before connection will be made and water turned on. If it is necessary to prepare a receptical for a meter, the consumer pays the actual cost of its construction. The municipalities served pay for fire protection at a stipulated amount per hydrant and also pay for water used in sprinkling the streets. Flushing sewers and public building supply are furnished without cost to the city.

ORGANIZATION

Under the general manager there are four departments, with the department-head, directly responsible to the manager. These are as follows:

The Maintenance and Repair Department under a superintendent who has entire charge of the physical plant, and supervision over all employees in the operation and maintenance of the system, except the office employees.

The Office Department in charge of a chief clerk who is responsible for the financial operations of the Company.

The Inspection Department under a chief inspector who is responsible for rates, and supervision over the consumers.

The Engineering Department under the charge of a chief engineer who has charge and supervision of all new construction and extensive replacement work.

Complete records are kept of the physical plant and daily reports made to the manager. The engineering department records all physical changes and keeps the general and detailed maps up to date. The inspection department keeps complete record of the rates and conditions of all house connections, keeping the records up to date by a system of continual house to house inspection, working in conjunction with the office force.

Courteous treatment of the public is demanded from all employees who are impressed with the belief that no one is so small, that the company can afford to make an enemy of him. The continual effort of every employee is to get and retain the good will of the public, and all we ask from them is fair treatment.

CONCLUSION

In a paper of this character it is impossible to discuss any details. Each division of a water plant such as this could be made the subject of a complete article, containing many interesting details to engineers and water works men.

From 1891 until 1920 more or less construction and extension work was done every year until every part of the plant was in duplicate, and ample reserve provided for emergencies and future growth. If time permitted many interesting points could be elaborated, the principal of which may be summarised as follows:

The successful use of copper sulphate in the treatment of the water in the various reservoirs to eliminate taste and smell from vegetable algae.

The successful use of electricity for pumping water under high pressure and relative advantage of the turbine pump over the rope drive, or any other reciprocating pump, when first cost is taken into consideration.

The advisability of the use of wooden pipe on account of its low first cost and low maintenance cost. That wooden pipe properly constructed has long life is demonstrated in our Basin Creek Line No. 1, which is still in splendid condition after being in continual service for thirty-four years.

The use of regulating chambers on the Big Hole influent pipe lines which resulted in enormous saving in first cost, and which have proved entirely satisfactory.

The use of lap welded steel pipe with welded joints installed in 1920 on Big Hole Line No. 2, which has proven eminently satisfactory, both in first cost and in maintenance.

The exclusive use of Matheson Joint welded steel pipe in our city system which has proved eminently satisfactory not only in first cost, but in cost of maintenance. The fact that some of this pipe has been in continuous operation for forty years indicates long life for that class of material.

In conclusion, from past experience in this and other water works construction, the writer believes that many of the difficulties and grief experienced by water works officials in the operation of a water works plant, can be eliminated by the use of good material and careful attention to the details of construction. Often low first cost is forced

on engineers against their better judgment, and invariably results in losses in maintenance and repairs after construction. It is a pleasure to state that in the construction of this plant, while often in financial straits, nothing was attempted unless the funds available were sufficient to procure the very best in workmanship and material, and of ample size. It is better to delay than to use cheap substitutes. The splendid condition of the plant today, parts of which have been in operation for over forty years, is a credit to the efficient corps of employees.

THE SIGNIFICANCE OF NITROGEN DETERMINATIONS IN SANITARY ANALYSIS[1]

By S. L. Neave[2] and A. M. Buswell[3]

Free ammonia is perhaps the oldest of the nitrogen-methods in sanitary analysis. As an end product in the bacterial metabolism of nitrogenous compounds, ammonia determinations may signify remote pollution of a water by organic matter. In sewage, similarly, free ammonia indicates the extent to which bacterial hydrolysis has proceeded. The difficulties in accurately determining ammonia by distillation have been appreciated. Mallet (1) in 1881 pointed out that: "In the case of waters containing urea, and also other amidated bodies such as leucine and tyrosine occurring among the products of putrefactive decay, some ammonia is so easily formed from these substances by boiling with sodium carbonate, or even without this addition, that it is impossible to distinguish sharply between pre-existing 'free' ammonia (of ammonium salts), and that formed by the action of alkaline permanganate, the so-called "albuminoid ammonia." Phelps (2), in a paper before the Laboratory Section of the American Public Health Association (1903), gave experimental data on the "free ammonia" of such substances as urea, gelatine, casein, egg albumin and peptone, showing that in all cases a small per cent of the nitrogen was liberated during distillation. Since the presence of sodium carbonate seems to promote these hydrolyses, various attempts (3) have been made to substitute a milder alkali, such as MgO, in its stead.

Direct nesslerization following copper sulphate clarification of course obviates this decomposition, but for the most accurate work nesslerization is an uncertain procedure when dealing with a mixture like sewage. Sulfur compounds and aldehydes produce too dark a color; protective colloids like proteins and peptones, which are not

[1] Presented before the Water Purification Division, Buffalo Convention, June 9, 1926.

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removed by the $CuSO_4$ treatment, inhibit color formation; many salts cause troublesome turbidities; and the small amount of amine nitrogen which is present even in fresh sewages is not included in the nessler color and consequently escapes determination. The present writers have successfully used aspiration of the ammonia into standard acid to avoid the defects of both the distillation and the direct nesslerization methods.

The albuminoid ammonia determination was proposed by Wanklyn, Chapman and Smith (4) in 1867 as a measure of the unhydrolyzed, or only partially hydrolyzed, nitrogenous matter in a water sample. The digestion with alkaline potassium permanganate was thought at first to completely destroy such substances with a quantitative liberation of ammonia. Frankland and Armstrong (5) at that time were advocating their combustion method for carbon and the rivalry between the two methods brought to light some interesting defects in each. The great weakness of combustion processes, of course, is the preparation of a dry residue without loss of volatile components. It was carefully tested out by Mallet (1) in a long series of analyses and the precautions found to be necessary for reasonable accuracy exclude it from the class of routine methods. Clark and Adams (6), however, used the combustion process with some success in studying the carbon content of sewage.

The incomplete hydrolysis of urea during the permanganate digestion was recognized by Wanklyn (7), but naïvely avoided by the statement that while pure urea was only partially decomposed, the impure urea of a sewage-polluted water showed no such resistance to hydrolysis. It was soon recognized, however, that the albuminoid ammonia nitrogen represented only a fraction of the total and various multiples of it have been adopted from time to time as measures of total nitrogen. Using a long series of known nitrogenous substances, Mallet (1) found the per cent of nitrogen liberated to vary from 0 to 95, with an average of 53. Even exhaustive treatment with alkaline potassium permanganate, in some cases requiring several days, did not give complete recovery of nitrogen. He concludes: "The value of the results by this process (alb. NH_3) depend more upon watching the progress and rate of evolution of the ammonia than upon determining its total amount." Phelps (2) also, in the report mentioned above, found wide variation in the recovery of ammonia from nitrogenous substances. In a series of sewage analyses, an average of 34.8 per cent of the total nitrogen

was liberated, though individual samples varied from 15.2 to 54.8 per cent. The formula of Fuller,

$$\text{Total N} = \frac{12 \times \text{alb.NH}_3}{\text{Free NH}_3}$$

was thus shown to be in error in some cases by 25 per cent for "water," but for sewage the error would be much greater.

The Kjeldahl process for total organic nitrogen requires no discussion. It is subject merely to the error in the free ammonia when determined on the residue from the ammonia distillation. It would seem more desirable to determine total nitrogen by the Kjeldahl method and subtract free ammonia from it to give total organic nitrogen, since in this way the amine-nitrogen (which may be high in an effluent from anaerobic processes) is included in the total nitrogen.

EXPERIMENTAL

Since the advent of more precise bacteriological methods, the nitrogen determinations in water analysis have lost their prestige. However, their offspring in sewage analysis still play a prominent part in treatment plant and stream pollution problems. The purpose of this paper is not to question the value of a nitrite or nitrate determination, but to inquire into the significance of the free and albuminoid ammonia and total organic nitrogen figures obtained in the routine analysis of domestic sewage.

The interpretation formerly placed upon these determinations in water analysis has been carried over into sewage practice. The bulk of the putrefactive material in sewage seems to be regarded as protein and protein derivatives. The free ammonia represents an end-product of bacterial decomposition; the albuminoid ammonia is attributed to peptones and amino acids; and the total organic nitrogen, as stated in Standard Methods (8) "comprises the nitrogen equivalent of nitrogenous compounds in various stages of hydrolysis, from complicated proteins to amino acids." Assuming the validity of this interpretation, the nitrogen would be expected to represent the concentration of putrefactive material or oxygen-requiring organic matter in the sewage. Our data for a purely domestic sewage, however, do not support these views.

The total nitrogen in the sewage can be almost entirely accounted

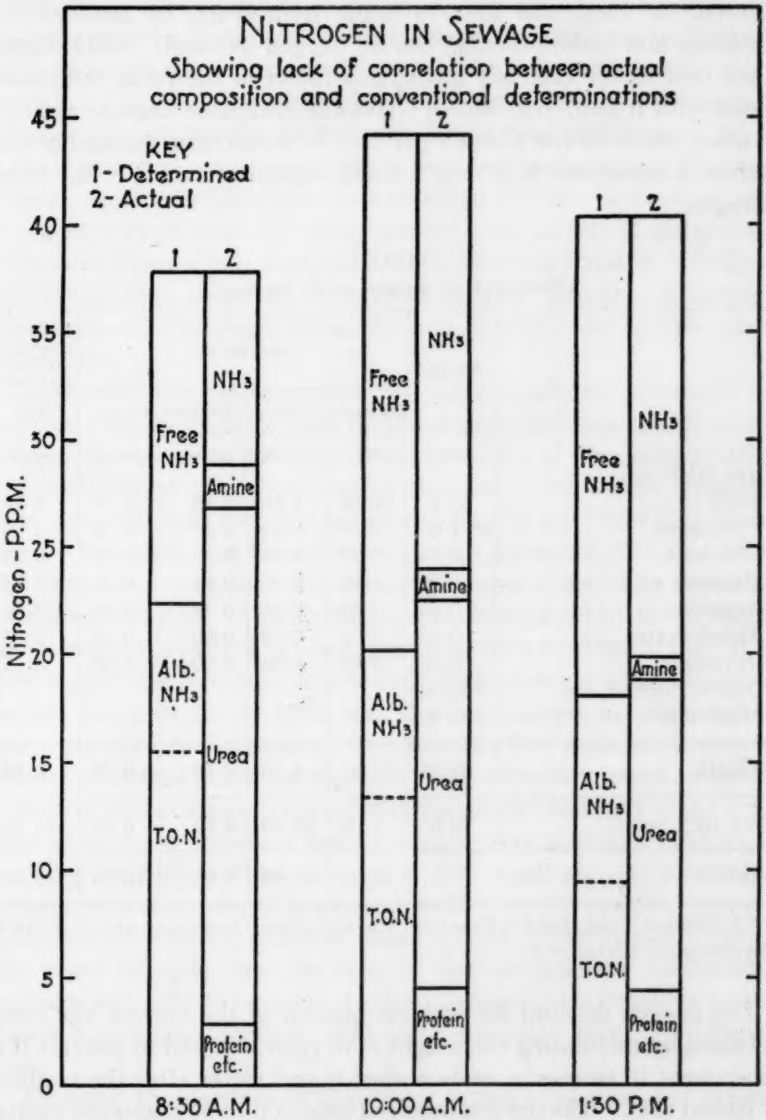

FIG. 1

for in the excreta of the population. A tabulation of the constituents of the excreta, as shown in the physiological chemistry texts (9, 10) reveals the following facts: over 90 per cent of the nitrogen is

excreted as urea, and urea in being hydrolyzed by bacteria to ammonia and carbon dioxide has no oxygen demand. Only about 9 per cent of the excreted nitrogen is found in the feces, but associated with it is 97 per cent of the total oxidizable organic matter. In other words all but about 3 per cent of the oxygen demand of the excreta is associated with only a small variable fraction of the total nitrogen.

TABLE 1

*Excretion by normal adult per day**

	WEIGHT	CONTENT OF				OXYGEN REQUIRED TO PRODUCE CO_2 H_2O and NH_3
		Nitrogen	Carbon	Hydrogen	Oxygen	
	grams	*grams*	*grams*	*grams*	*grams*	*grams*
Urine (1500 cc.):						
Urea	35.0	16.35	7.00	2.33	9.33	0.00
Creatinine	1.0	0.37	0.42	0.07	0.14	0.85
Uric acid	0.75	0.25	0.27	0.02	0.21	0.21
Hippuric acid	0.70	0.05	0.45	0.04	0.19	1.13
Ammonia	0.65	0.53	0.00	0.12	0.00	0.00
Thiocyanates	0.15	0.02	0.02	0.00	0.00	0.05
Oxy-acids	0.06	0.00	0.04	0.00+	0.02	0.11
Oxalic, indican, etc	Traces					
Mineral ash	30.0					
Totals	68.31	17.57	8.20	2.58	9.89	2.35
Feces (dry basis)	20.0	1.80	26.80	4.07	6.66	94.25
Totals		19.37	35.00	6.65	16.55	96.60

* Compiled from Hawk's Practical Physiological Chemistry and Mathew's Physiological Chemistry.

The oxygen demand for each component of the excreta has been obtained by calculating the weight of oxygen required to convert the component to ammonia, carbon dioxide and water after the method of Rideal (11). The oxygen required totals up to 97 grams per capita per day. The fact that this daily oxygen requirement compares favorably with statistical data obtained in stream pollution studies (12) is merely coincidence or balancing of errors, since our calculations disregard the oxygen demand of soap, paper, and similar material in the sewage.

Realizing then that urea is the main nitrogenous component discharged into the sewer and that it is slowly broken down by bacteria into ammonia, the nitrogen figures can be more adequately interpreted. The free ammonia represents urea already decomposed plus a litle chemically hydrolyzed during the distillation. Albuminoid ammonia represents further chemical hydrolysis of the urea; it is a notoriously indefinite determination and the explanation now becomes evident when the many factors, such as rate of distillation, concentration of alkali used, etc., which influence the slow hydrolysis are taken into account. The total organic nitrogen, of course, represents total nitrogen minus the free ammonia and includes most of the urea.

To verify this interpretation we have analyzed a number of domestic sewage samples both by the routine methods and by determining the separate nitrogenous components of the sample using the methods of the physiological chemist. The actual ammonia was aspirated into standard acid according to the Folin (13) procedure. The urea was then converted into ammonia (14) by adding the enzyme, urease, and the resulting ammonia similarly aspirated into standard acid. Total nitrogen was determined by the Kjeldahl method and the sum of the ammonia plus urea subtracted from it to give the protein fraction. Three such analyses are graphically represented in figure 1. In each case the constituents are reported in parts per million of nitrogen. The so-called free ammonia is seen to consist of actual ammonia together with a small amount of amine (which is unimportant in the present discussion) and part of the urea. The albuminoid ammonia results mainly from destruction of some urea by the boiling alkali, though a very small amount also arises from certain compounds grouped together as the protein fraction. This protein fraction, being as stated merely the difference between the total nitrogen and the sum of the components determined, includes not only the traces of other nitrogenous substances in the excreta, but also nitrogen containing material from the kitchen sink.

Although the purpose of this paper is not to discuss the nitrate determination, the predominance of urea introduces one error into the aluminium reduction method which deserves mention. As pointed out in Standard Methods, "during the long alkaline digestion some proteolysis may take place, giving high results." It is, however, not so much a proteolysis as a hydrolysis of urea especially during the

distillation of the resultant ammonia. For example, our Imhoff tank effluent has consistently shown a nitrate content of 0.2 to 2.0 p.p.m. over a period of six months, while the colorimetric method has shown no nitrate. Accordingly whenever conditions pemit the colorimetric method would seem to be preferable to the reduction method.

To summarize, therefore, our analyses show, first that the main nitrogenous components of sewage are urea and ammonia; second, that these components bear no constant relation to the oxidizable organic matter; third that the albuminoid ammonia test, since it measures an indefinite portion of the urea, is worthless; and fourth the free ammonia also includes some of the urea and is erroneous if the distillation process is used. If it is considered desirable to continue the collection of nitrogen data in routine analysis, suitable methods could be chosen by Committee No. 1 for the accurate determination of the important nitrogenous constituents, and these methods adopted in place of the present indefinite ones.

One further point arising out of this discussion deserves mention; namely, the value of nitrogen determinations for detecting pollution in drinking water. We have collected a little data on this point, but not sufficient yet to make any final statement. Two cases naturally arise: if the water is polluted by sewage so recently that the urea has not been entirely hydrolyzed, the nitrogen determinations are subject to the errors discussed for sewage; however, the application to such waters of a method for the determination of urea alone, would give absolute evidence of sewage pollution, and it should not be very difficult to work out such a method.

On the other hand, if pollution were remote and all the urea had been broken down, the free ammonia should be less subject to error. But the albuminoid ammonia still seems to be of little importance. Our own tests have thus far confirmed some of the older literature (1, 2, 7) in showing that many organic substances slowly give up their ammonia when boiled with alkaline permanganate; and in this decomposition there is nothing to distinguish sewage material from decomposing plant remains. Similarly pollution of a water supply by an industrial waste containing proteins or peptones would not give any characteristic albuminoid ammonia result.

With the delicate analytical methods of the biochemist now at our disposal and the growing importance of river and lake pollution, there is an urgent need for the complete revision of our nitrogen

determinations, with a view either to correcting their defects or abandoning them in favor of more significant determinations.

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SOCIETY AFFAIRS

FLORIDA SECTION

Waterworks operators, superintendents and engineers in the waterworks field met on November 18, 1926 in Tampa and organized the Florida Section of the American Waterworks Association. Over sixty men from all sections of Florida attended and took active part in the proceedings.

Papers were presented by Eugene Masters, president of the Florida League of Municipalities and city manager of St. Augustine; W. E. Darrow, consulting engineer of Winter Haven; Frank Schwabel, superintendent of the Clearwater waterworks. Mayor Wall welcomed the members of the association.

A paper submitted by Fred J. Stewart, city engineer of Hollywood, on the result of the hurricane to the waterworks men, brought forth much discussion as to the need for proper housing of waterworks records and the lack of knowledge of valve locations and other features of the distribution system.

A luncheon at the Katinka was followed by an inspection trip to the waterworks plant at Barritt Park. At the luncheon Commissioner Barritt spoke on the new Tampa waterworks. At the plant the party was shown all the details of operating procedure by C. C. Humphreys of the Waterworks Department. Comments on the neatness and general appearance of the plant could be heard on all sides. A short business session was held and the following officers were elected: Anson W. Squires, Tampa, Chairman; Eugene Masters, St. Augustine, Vice-Chairman; E. L. Filby, Jacksonville, Secretary-Treasurer.

Directors chosen were: C. C. Brown, Lakeland; A. P. Michaels, Orlando; W. A. Richards, Daytona Beach; F. W. Line, St. Petersburg; L. B. Duane, Sanford; F. J. Steward, Hollywood.

A constitution was adopted and it was decided to hold a spring and fall meeting with Hollywood as the next meeting place for the April meeting.

Those attending the meeting were invited by various manufacturers

to a dinner at the Hillsborough Hotel. The Association adjourned after the evening entertainment. F. P. Larmon spoke on the new plant at Ft. Pierce during the dinner.

E. L. Filby,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Building a Valve for a Pressure of Three and a Third Tons. D. H. W. Felch. Chem. & Met. Eng., 33: 10, 596, October, 1926. Working pressure on pumps was increased from 1,500 pounds to 2,000 pounds. The valves as originally furnished were of the barrel type, high-tensile strength nickel alloy. The seats of one of the three pumps were of a good grade of cast gun bronze, of the second pump they were of the same nickel alloy as the valves, and of the third they were of hardened tool steel. After the pumps were put into service the nickel alloy and gun-bronze seats gradually pushed through the cylinder blocks. The hardened tool steel in the third pump remained in place, but the water being highly corrosive they pitted badly. Valves of a copper-aluminum-iron alloy and seats of copper-nickel-iron-chromium alloy were made. The valves showed slight pitting but the seats showed no erosion.—*John R. Baylis.*

Caustic Embrittlement of Steel. S. W. Parr and F. G. Straub. Chem. & Met. Eng., 33: 10, 604–7, 1926. The paper is a brief abstract of Bulletin 155 of the University of Ill. Embrittlement cracks follow grain boundaries. They do not follow the line of maximum stress, but start on the dry side of the plate. They run, in general, from one rivet hole to another, are irregular in direction, and never extend into the body of the plate beyond the lap of the seam. There is no elongation of the plate. The cracks always occur below the practical water level in seams under tension and at places where the high localized stresses occur. They occur in plates having perfect chemical composition and physical properties. There are certain areas, principally in the Middle and South West United States where embrittlement is more evident than in others. Cases that can be traced to water treatment are comparatively few. The type of boiler seems to be without effect as far as tendency towards embrittlement is concerned. The importance of the sulfate-carbonate ratio in preventing embrittlement has been studied in the Univ. of Ill. power plant over a period of 10 years. The sulfate-carbonate ratio of the feed water is maintained at two by neutralizing about 70 per cent of the sodium carbonate alkalinity with sulfuric acid. After 10 years of operation on this treatment the drums were found to be in perfect condition.—*John R. Baylis.*

Boiler Corrosion and Possible Combative Measures. W. M. Barr and R. W. Savidge. Chem. & Met. Eng., 33: 10, 607–8, October, 1926. The high-

priced alloys do not appear to be an economical substitute for steel. After scale accumulates the water is kept from contact with the steel and the high temperature on the firebox side soon overheats the metal where the scale is thickest. Burning of the metal makes it more easily attacked by the corrosive elements of the water. When the scale cracks off water comes in contact with the burned metal and ideal conditions are set for electrolytic action. Dissolved oxygen, when introduced into the boiler with the feed water, is one of the principal causes of corrosion. A great improvement has been effected by passing the water through an open feed water heater in which the temperature was held above 200°F. The principal benefit of water treatment is the removal of incrusting matter. High concentrations of sodium salts appear to accelerate corrosion and in practice it is desirable to operate locomotive boilers on concentrations below 3500 to 4000 parts per million. Further reduction of concentration is not economical on account of fuel loss. Present practice in treating feed water is to remove the incrusting solids and carry a slight excess of caustic soda on account of its inhibitive effect on corrosion. Too great an excess of caustic soda or sodium carbonate may cause foaming.—*John R. Baylis.*

Comparative Degree of Thyroid Enlargement Among School Children in Two Sections of Louisiana. L. C. Scott. Quarterly Bulletin, Louisiana State Board of Health, **17**: 2, 72, June, 1926. A thyroid survey, conducted among the school children of four parishes in Louisiana, indicates iodin deficiency. This is greater in the river parishes of St. James and St. Charles, where rain water is used for drinking, than in the forest parishes of St. Tammany and Washington, where the water supply comes from deep wells.—*G. C. Houser.*

Troubles. E. L. Filby. Health Notes, Florida State Board of Health, **18**: 8, 112, August, 1926. A district engineer of Florida State Board of Health accidentally discovers and eliminates cross-connection between mains of a privately owned and operated water company and those of a municipally owned high-pressure fire protection system, using grossly polluted lake water. Connection had been made inside a power plant, without knowledge of water company or of city.—*G. C. Houser.*

Typhoid Epidemics in Two Pennsylvania Towns. Listening Post, Penn. Dept. of Health, **4**: 38, 21 and 23, May and June, 1926. Water-borne typhoid epidemics recently occurred in New Milford and Glenshaw. New Milford, with a population of 600, had 74 cases and 4 deaths. Glenshaw had 15 cases of typhoid at one time, all children with a single exception. Here the source of infection proved to be a school well.—*G. C. Houser.*

Court Sustains Order re Water Supply Pollution. Connecticut Health Bulletin, **40**: 5, 127, May, 1926. Inspection of the Winsted public water supply having disclosed a serious case of pollution, State Department of Health granted a hearing on December 21, 1925, to property owner concerned. In spite of the fact that his property drained into brook tributary to Winsted reservoir, it was found that in 1925 a barnyard had been located very close to

the brook. An order for the removal of the barnyard, issued by the department, was sustained by the court on March 30, 1926.—*G. C. Houser.*

Appraisal of Health Service for the Year 1925 in Fifteen Illinois Cities. Ill. Dept. of Pub. Health, Ill. Health News, 12: 5 and 6, May–June, 1926. Water supply is one item dealt with in survey of public health services provided by 15 cities with populations ranging from 30,000 to 100,000. In all except two of these public water supply meets governmental standard. In Joliet, where the storage basins are subject to pollution, supply has been given provisional certification only. In Moline, the water supply does not fully meet requirements as to safety, owing to deficiency in construction and size of purification plants.—*G. C. Houser.*

Value of Automatic Sprinkler Systems. L. S. Jones. Virginia Municipal Review, 3: 10, 392, October, 1926. Gives many arguments for installation of automatic sprinkler systems for fire prevention in Richmond, Va. Examples given of saving effected in cost of insuance after installation of sprinklers. Depending upon whether temperature in a plant may, or may not, go below freezing point, the dry pipe, or the wet pipe system should be used.—*G. C. Houser.*

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Floods Create Health Problem. C. D. Gross. Illinois Health News, 12: 10, 345, October, 1926. Slowly rising streams seldom cause deaths by drowning but neglect of sanitation during and following high water may cause epidemics of disease, such as typhoid fever. During flood stages, drinking water should be secured only from wells known to be safe. Water from wells near flood water should be boiled before use for drinking. After the flood passes, dug wells must be sterilized with chloride of lime and thoroughly cleaned out.—*G. C. Houser.*

Survey of Lake Resorts. Public Health News, New Jersey Dept. of Health, 11: 11, 260, October, 1926. A survey of lake resorts shows great need for better supervision over the sanitation of the large number of summer resorts in New Jersey. At one lake the shallow wells which supply drinking water were menaced by nearby privies and cesspools. At another resort the cesspools receiving sewage from two hotels were found to be overflowing directly into the lake which at times is used as water supply for the Borough of Branchville. Theoretically, work of supervision should be performed by local health officials.—*G. C. Houser.*

Suburban Sanitary Engineering. H. B. Costill. Public Health News, New Jersey Dept. of Health, 11: 10, 216, September, 1926. Water supplies

of bay shore and ocean front communities are usually obtained from driven wells. These waters usually are high in carbon dioxide and iron, making the water offensive to the user. Problem arises whether Dept. of Health shall consider the iron and CO_2 contents of a water supply as influencing "the purity of the supply of potable water" furnished by a water plant.—*G. C. Houser.*

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Influence of Metallic Elements on the Corrosion of Iron and Steel. YUHATIRÔ UTIDA and MAKOTA SAITÔ. Sci. Repts. Tokohu Imp. Univ., 14: 3, 295–312, 1925. (In English.) From Chem. Abst., 20: 573, February 20, 1926. Effect of nickel, chromium, silicon, copper, manganese and tungsten on corrosion of iron and steel was studied. Samples were prepared by casting pure iron alloyed with above metals, and castings were cut into rods 4 to 5 cm. long and 5 mm. in diameter. Clean, polished rods were immersed for 24 hours at room temperature in beakers containing 10 per cent nitric, hydrochloric or sulphuric acid and loss in weight recorded. Oxidation at high temperatures was

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measured by placing specimens for 1 hour in electric furnace at 1100° and recording increase in weight. Iron containing 14 per cent chromium is not attacked by nitric acid, but is easily corroded by hydrochloric acid of same concentration. Increasing amounts of nickel, silicon and tungsten decrease corroding action of acids and oxidation in air at 1100°. Addition of manganese always increases corrosion. Copper increases attack by nitric acid, while hydrochloric and sulphuric acids affect copper alloys little or not at all. While iron containing chromium is easily corroded by hydrochloric acid and iron containing nickel very little, combined effect of both produces alloys highly resistant to hydrochloric and sulphuric acids. For steels the best results in hydrochloric acid were obtained when carbon content varied between 0.1 and 0.7 per cent, and in sulphuric acid when 0.3 per cent carbon was present. Mixed acids corrode alloys to greater extent than pure acids. Alloy containing 0.4 per cent carbon, 20 per cent chromium and 8 per cent nickel, resembling Krupp's rustless steel V_2A, has best corrosion-resisting properties, both in pure and mixed acids.—*R. E. Thompson.*

The Use of Lime for Treating Public Water Supplies to Prevent Corrosion and "Red Water." J. R. BAYLIS. Rock Products, **28:** 18, 59–60, 1925. From Chem. Abst., **20:** 637, February 20, 1926.—*R. E. Thompson.*

A Sensitive Biological Indicator for the Chemical Condition of Inland Water. AUGUST THIENEMANN. Naturwissenschaften, **13:** 868–9, 1925. From Chem. Abst., **20:** 637, February 20, 1926. It has been observed that the very common water flea, *Gammarus pulex*, only lives in those waters that have relatively high oxygen content, combined with rapid oxygen replenishment. It is sensitive to all inorganic pollution and to decaying organic matter. Even more sensitive test objects for quality of water are the epizoic protozoa, *Spirochona gemmipara* and *Dendrocometes paradoxus*, occurring on the "Kiemenblättchen" of Gammarus. They are relatively resistant to temperature changes but do not appear when appreciable sodium chloride, acids, or ogranic pollution is present, even when the flea itself is unharmed.—*R. E. Thompson.*

Difficulties Encountered in Purifying Small Quantities of Boiler Feed Water. G. PARIS. Chimie et industrie, Special No. 143, September, 1925. From Chem. Abst., **20:** 637, February 20, 1926. Lime-soda process can hardly give good results with flow of less than 5 tons an hour. Processes using addition of dissolved reagent can give good results with flows down to 600 liters an hour. Zeolite processes give good results with flows of less than 500 liters per hour.—*R. E. Thompson.*

Modern British Practice in Water Softening. IV. Lime Cream and Soda Ash Plants (Kennicott, Lassen-Hjort, Paterson and Porter). D. BROWNLIE. Ind. Chemist, **1:** 495–500, 1925; cf. C. A. **19:** 3553. From Chem. Abst. **20:** 637, February 20, 1926.—*R. E. Thompson.*

Lime Treatment of Water for the Manufacture of Raw Water Ice. A. S. BEHRMAN. Rock Products, **28:** 18, 57–8, 1925. From Chem. Abst., **20:** 637, February 20, 1926.—*R. E. Thompson.*

Sodium Silicate as a Corrosion Preventive. R. P. RUSSELL. Proc. Am. Assoc. Textile Chem. Colorists, 1926, 47–51; Am. Dyestuff Rept., **16:** 61–5. From Chem. Abst., **20:** 896, March 20, 1926.—*R. E. Thompson.*

Results of Tests with Alcement Lafarge. A. F. R. LUND. Teknisk Ukeblad, **72:** 324–7, 335–40, 350–2, 1925. From Chem. Abst., **20:** 651, February 20, 1926. Alcement, manufactured by Sté. Ame. des Chaux & Ciments de Lafarge et du Teil, France, was compared with normal portland cement. Setting properties were normal and soundness was satisfactory. Hardening was extremely rapid, and major portion of ultimate strength was reached in 24 hours. After 28 days, tensile strengths of the two sand mortars were nearly alike, with only 10 per cent difference in favor of alcement, but crushing strength of latter was nearly twice that of portland cement mortar. In concrete the superiority of alcement as regards crushing strength was still greater. Humic acids in the sand have only a small influence upon quality of this mortar. It was very resistant to fire and water, and was slightly more resistant to wear. Large test specimens of concrete, plain and reinforced, proved great and general superiority of alcement.—*R. E. Thompson.*

Operation of Swimming Pools. W. WEICHARDT and O. ULSAMER. Gesundh. Ing., **48:** 283–5, 1925. From Chem. Abst., **20:** 638, February 20, 1926. Purification of pool water with chlorine and by filtration is practiced in Germany. Excess of chlorine at all times, and a bacterial count resembling that of drinking water, recommended. Results given for pool at Nürnburg.—*R. E. Thompson.*

Lime in the Treatment of Dye and Textile Wastes. F. D. SNELL. Rock Products, **28:** No. 18, 61–2, 1925. From Chem. Abst., **20:** 668, February 20, 1926. Description of acid neutralization and coagulation of dye wastes by iron or aluminum sulfate and lime. High calcium lime is preferable to magnesian lime.—*R. E. Thompson.*

The Radioactivity of the Mineral Waters of Hammam Meskoutine, Algeria. I. POUGET and D. CHOUCHAK. Compt. rend., **181:** 921–3, 1925; cf. C. A., **19:** 3214. From Chem. Abst., **20:** 702, March 10, 1926. Radioactivity of several springs in district varies from zero to 13.7 millimicrocuries per liter.—*R. E. Thompson.*

Modern Developments in Steels Resistant to Corrosion. W. H. HATFIELD. Engineering, **120:** 657–60, 1925. From Chem. Abst., **20:** 731, March 10, 1926. Theories of corrosion are briefly described. Modern conception is that nature of first thin oxide film determines subsequent chemical action. Corrosion tests are always disturbed by accelerating or retarding factors, such as contact of specimen with solid body, improper aëration, or change of composition of medium. Data are given on results of tests of alloys and corrosion-resisting steels.—*R. E. Thompson.*

The Economy in the Electric Arc Welding of Ingot Iron. KARL MELLER. Siemens-Z., **5:** 457–64, 1925. From Chem. Abst., **20:** 734, March 10, 1926.

Recent increasing application of electric arc for welding ingot iron is due to better economy in the working method. Welding is at present only undertaken with metal electrodes, directly molten into the seams. Data given in regard to technology and efficiency. Electric arc welding of an oil tank showed an actual saving of 50.6 per cent over autogenous welding.—*R. E. Thompson.*

The Radioactivity of the Water of the Thermal Spring at Chaudfontaine, Belgium. Eug. Prost. Rev. universelle mines; **8:** (7) 21–8, 1925. From Chem. Abst., **20:** 789, March 10, 1926. Results of recent analysis given. Experiments revealed presence of radium emanation, content being of order of 2–3 millimicrocuries per liter. The water freed of this emanation by boiling showed slight activity after several days, though it was not proved whether this was due to residual emanation or to presence of radium in water.—*R. E. Thompson.*

Chemical Supervision of Plants for Softening of Boiler Water. A. Splittgerber. Z. Nahr. Genussm. **50:** 142–77, 1925. From Chem. Abst., **20:** 790, March 10, 1926. Review, with excellent bibliography, of soda, lime-soda, and permutite processes, including discussion of methods of determination and allowable limits of various impurities.—*R. E. Thompson.*

The Problem of Sewage Disposal in the Ems and Ruhr Territory. Jan Smit. Chem. Weekblad, **22:** 537–41, 1925. From Chem. Abst., **20:** 790, March 10, 1926. Problem is particularly difficult because of dense population and network of coal mines. Phenols and chlorophenols from gas, coke, and other industries threaten the fisheries, not so much by direct toxic effect as by impairing taste of the fish. They are removed from sewage water by biological oxidation on porous surfaces and aëration according to Fowler and Bach, or extracted with benzene from the gas water.—*R. E. Thompson.*

Separation of Small Quantities of Calcium from Large Quantities of Magnesium in Water. H. Noll. Chem.-Ztg., **49:** 1071–2, 1925. From Chem. Abst., **20:** 790, March 10, 1926. Some 65 careful experiments showed that the oxalate method, which has recently been criticized, is indeed satisfactory, provided separation is effected in 200 cc. of water when not over 125 mgm. of MgO is present.—*R. E. Thompson.*

Treating Alumino-Silicate Minerals for Water-Softening. Herman Reinbold. U. S. 1,570,006, January 19, 1926. From Chem. Abst., **20:** 790, March 10, 1926. Minerals of the bentonite variety are ground, sized, calcined, treated with a solution of aluminum compound such as aluminum sulfate, sodium hydroxide, and sodium chloride, and dried.—*R. E. Thompson.*

Apparatus for Deaërating Boiler Feed-Water, etc. Griscom-Russell Co., Brit. 234, 448, May 24, 1924. From Chem. Abst., **20:** 791, March 10, 1926. A portion of the incoming liquid is distributed in the apparatus in form of curtain of falling drops through which the evolved gases and vapor pass to condense latter.—*R. E. Thompson.*

The Science of Ground Water Supplies. G. THIEM. Z. Ver. Gas-u. Wasserfach, **65**: 166–9, 1925. From Chem. Abst., **20**: 956, March 20, 1926. Most German cities use ground water as civic supplies.—*R. E. Thompson.*

Ammoniacal Liquor and Noxious Effluents from Distillation Plants. J. W. YOUNG. Annual Report of Alkali, etc., Works Inspector. Gas World, **82**: 647–50, 1925. From Chem. Abst., **20**: 813, March 10, 1926. Liquors from vertical report systems are highly charged with higher tar acids, color-producing substances, etc. Liquors from horizontal retort plants are relatively free from such substances. Phenol is considered the most obnoxious constituent. Its removal is effected by scrubbers in which flue gases are injected into the base, the injector working at steam pressure of 70 pounds. Liquor enters at 91° and leaves at 95°. Phenol volatilization efficiency of 94 per cent and reduction in oxygen absorption value of 34 per cent is claimed.—*R. E. Thompson.*

Potentiometer for Routine Determinations. C. W. G. HETTERSCHIJ. Chem. Weekblad, **23**: 3–4, 1926. From Chem. Abst., **20**: 845, March 20, 1926. Apparatus described has advantage of cheapness, simplicity, direct pH reading, and sturdiness. Measuring range is pH 3.5 to 8.5. Rheostat and resistance unit for rough and fine regulation are arranged on both sides of circular constant resistance unit, subdivided into equal manganin coils with 100 dials. Thus the pH difference between 2 dials is 0.05. Accuracy can be further increased by taking average of 2 galvanometer readings.—*R. E. Thompson.*

A Hydrogen Electrode for Flowing Liquids. A. H. W. ATEN and P. J. H. VAN GINNEKEN. Rec. trav. chim., **44**: 1012–38, 1925. (In English.) From Chem. Abst., **20**: 847, March 20, 1926. A H-electrode developed by authors (Tijdschr. Alg. tech. Ver. Beetwortelsuikerfabr. en. Raff. **5**: 89, 1924–5) is described and illustrated, and its application outlined.—*R. E. Thompson.*

The Value of the Lehmann Microelectrode. G. E. VLADIMIRO and M. J. GALIVIALO. Biochem. Z., **160**: 101–4, 1925; cf. C. A. **18**: 2. From Chem. Abst., **20**: 847, March 20, 1926. Good results were obtained in determination of pH in carbon dioxide-free solutions. When carbon dioxide was present, the method compared favorably in exactness and speed with other methods.—*R. E. Thompson.*

The Metallurgical Aspects of Modern Boiler Practice. L. P. SIDNEY. Chem. Age (London), **14**: 2–3, 1926. From Chem. Abst., **20**: 893, March 20, 1926. Growing necessity of fuel economy is causing changes in boiler pressures and temperatures and, therefore, in boiler construction. Consensus of opinion is that strength of boiler plate can be satisfactorily increased by use of steel of high quality containing certain amounts (as yet undetermined) of nickel and chromium.—*R. E. Thompson.*

The Nature of the Protective Film of Iron. T. FUJIHARA. Trans. Am. Electrochem. Soc., **49**: 1926 (preprint); cf. C. A. **18**: 1970, 2677. From Chem.

Abst., **20**: 895, March 20, 1926. When a drop of distilled water is placed on polished surface an uncorroded rim appears at edge of drop. Author found that liquid on this uncorroded portion was alkaline in reaction due to presence of soluble ferrous hydroxide. Presence of carbon dioxide destroys this protective film by neutralizing the alkalinity, permitting corrosion to continue.—*R. E. Thompson.*

The Rustproofing of Materials. M. E. McDonnell. Mech. Eng., **47**: 875–80, 1925. From Chem. Abst., **20**: 895, March 20, 1926. Tests by Pennsylvania Railroad showed steels which contained 0.25 per cent copper to be twice as resistant in atmosphere as non-copper-bearing steel. Paint on steel coaches is based on in steam sheds at 120° and lasts 3 years compared with 1.5 years for air-dried finishes.—*R. E. Thompson.*

Coating Sheet Iron with Lead. Apparatebau, **37**: 327–8, 1925. From Chem. Abst., **20**: 896, March 20, 1926. Pickel in sulfuric acid bath, wash free from acid, immerse in antimony chloride solution until surface turns deep black, wash, treat with zinc chloride, dip in molten lead and cool in oil. Coating becomes so firmly attached that bending and hammering will not detach it. Cf. C. A. **16**: 1068, 2104, 3627; **18**: 524, 2679.—*R. E. Thompson.*

ABSTRACTS, SUB-COMMITTEE NO. 9

Joint Research Committee on Boiler Feedwater Studies

Composition of Water and Injurious Constituents it Contains. (Composition des eaux naturelles et éléments nuisibles qu'elles peuvent contenir). J. Guth. Assns. Françaises de Propriétaires d Appareils à Vapeur, Bul. No. **25**: July, 1926, pp. 161–180, 3 figs. Discusses chemical constituents of water and importance of accurate analysis; gases, minerals and organic compounds; water hardness, temporary and permanent; typical feedwater analysis.

Recorder for Dissolved Oxygen in Feed Water. Engineering, **122**: 3174, Nov. 12, 1926, p. 610, 2 figs. Instrument, known as Cambridge dissolved-oxygen recorder, gives continuous record of quantity of oxygen present in feed water on chart calibrated in cubic centimeters per liter so that defects on feed system which might otherwise remain unnoticed for long periods, may be instantly detected and remedied.

The Preservation of Boilers and Condensers from Incrustation and Corrosion by Means of Electric Current. J. Frankfurt. Electritchestvo, 7, July 1926, pp. 315–318, 5 figs. Review of methods of water purification used in boiler feeding and employed in Russia and other countries. (In Russian.)

Treatment of Feed Water. Natl. Elec. Light Assn. Report, no. 256–71, July, 1926, 30 pp., 21 figs. Results in several plants with use of sodium aluminate as accelerator in outside treating systems, and experience with acid-treating apparatus used in connection with zeolite system; scale troubles in

interdeck and radiant-heat-type superheaters; boiler-scale troubles in high-pressure plant, which has been endeavoring to maintain suggested sulphate-carbonate ratio; caustic-embrittlement troubles with boilers at Long Beach steam plant of Southern California Edison Company; acid treatment of boiler water as developed by Dallas Power and Light Co.

Measuring Boiler Load Without Flow Meters. J. D. JENKINS. Power, **64**: 18, Nov. 2, 1926, p. 658. Author makes use of principle that what comes in minus what goes out must equal what stays; this principle is applied to dissolved solids in water entering boiler; from analysis of feed and boiler waters and knowledge of time, boiler has been on and quantity of blowdown, evaporation can be calculated.

Overcoming Scale in Boilers. D. COCHRANE. Power House, **20**: 20, October 20, 1926, pp. 15–16. Author shows some causes of scale formation and outlines various methods to overcome its effects, dealing particularly with troubles caused when oil and scale combine in boiler.

The Prevention of the Formation of Boiler Scale. Engineering, **122**: 3168, October 1, 1926, pp. 415–416, 5 figs. Water-cooled type of apparatus known as filtrator, which is now being used to prevent formation of boiler scale and for removal of old deposits; process consists in introducing water-soluble constituent of linseed into water which is fed into boiler, in such a way that no oil enters with it; with new modification, old trouble has been entirely eliminated; details of other modifications.

Condenser Tube Scaling Tools. Engineering, **122**: 3174, November 12, 1926, p. 611, 2 figs. Describes tool for removal of condenser scale which has proved particularly useful in power station work, where matter of some 8000 tubes perhaps 17 feet long, may have to be dealt with.

Means of Preventing Boiler Pitting. C. H. KOYL. Ry. & Locomotive Eng., **39**: 10, October, 1926, pp. 278–279. Author shows that it is easier to exclude oxygen from locomotive boiler than from stationary boiler or any closed water system; on districts with treated or naturally soft water there is no difficulty in preventing pitting with present open heater nor in materially reducing it by closed heater or even with closed-overflow injection properly chosen and properly operated.

Investigation of Strongly Corroded Brass Condenser Tubes (Untersuchungen von Messingkondensatorrohren mit starker Korrosion). M. SCHWARZ. Korrosion u. Metallschutz, **2**: 1, January, 1926, pp. 8–17 17 figs. Examination of tubes from two power plants showed basic zinc carbonate in corroded spots and experiments showed that cooling water attacked beta mixed crystals of brass.

NEW BOOKS

Der Beton. RICHARD GRÜN. Berlin: Julius Springer. Paper; 186 pp. Reviewed in Eng. News-Rec., **96**: 823, May 20, 1926.—*R. E. Thompson.*

Einflüsse auf Beton. F. HUNDESHAGEN, OTTO GRAF and A. KLEINLOGEL. Berlin: Wilhelm Ernst & Sohn. Paper; 448 pp.; 19.5 M. Cloth, 21.6 M. Reviewed in Eng. News-Rec., **96**: 995, June 17, 1926.—*R. E. Thompson.*

Lead Poisoning. JOSEPH C. AUB, A. S. MINOT, LAWRENCE T. FAIRHALL, and PAUL REZNIKOFF. Baltimore: The Williams & Wilkins Co. $4. From Chem. Abst., **20**: 636, February 20, 1926.—*R. E. Thompson.*

Neuere Volksbäder. P. BÖTTGER. Berlin: Deutschen Gesellschaft für Volsbäder. 56 pp. Reviewed in Gesundh. Ing., **48**: 541, 1925. From Chem. Abst., **20**: 638, February 20, 1926.—*R. E. Thompson.*

Wasserversorgung und Brunnenbau. GROH. Berlin: Laubsch and Everth. 173 pp. M. 5.50 Reviewed in Gesundh. Ind., **48**: 270, 1925. From Chem. Abst., **20**: 638, February 20, 1926.—*R. E. Thompson.*

The Chemistry of Power Plant. W. M. MILES. London: E. Benn, Ltd. 144 pp. 6s. Reviewed in Ind. Chemist, **1**: 502, 1925. From Chem. Abst., **20**: 658, February 20, 1926.—*R. E. Thompson.*

Korrosion and Rostschutz. EMIL MAASS. Berlin, S. W. 19: Beuth Verlag. 35 pp. R.M. 1. From Chem. Abst., **20**: 734, February 20, 1926.—*R. E. Thompson.*